



Digitized by the Internet Archive
in 2019 with funding from
University of Alberta Libraries

<https://archive.org/details/Richardson1965>

515
5
8

THE UNIVERSITY OF ALBERTA

GROWTH AND RELATIONSHIP OF THE JAWS, AND
ERUPTION OF THE TEETH FROM THREE MONTHS
TO TWO YEARS OF AGE

BY

ALAN S. RICHARDSON

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF SCIENCE

DEPARTMENT OF DENTISTRY FOR CHILDREN
FACULTY OF DENTISTRY

EDMONTON, ALBERTA

APRIL, 1965

UNIVERSITY OF ALBERTA
FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read,
and recommended to the Faculty of Graduate Studies for
acceptance, a thesis entitled Growth and
Relationship of the Jaws, and Eruption of the Teeth
from Three Months to Two Years of Age.
submitted by Alan S. Richardson.
in partial fulfilment of the requirements for the degree
of Master of Science.

ABSTRACT

The purpose of this study was to find a suitable method for studying growth and development of the human dentition during the first two years of life, and having established such a method, to study in detail:

1. Changes in dimension of the maxillary and mandibular dental arches.
2. Changes in dimension of the vault of the palate.
3. Occlusal relation of the dental arches.
4. Eruption and movement of the deciduous teeth.

Dental casts were obtained from 38 healthy Edmonton children, during a 21-month period. In all but five cases the first cast was obtained prior to the eruption of any deciduous teeth. Subsequent casts were obtained at six-month intervals, giving a total of one hundred and ten pairs of dental casts for the entire group. Growth changes were studied by means of direct measurements of the casts and by symmetrograph and pantograph tracings. Some of the observations are as follows:

There is an active growth period in the dental arches during the first six months of life followed by a leveling off in the anterior region. Active growth continues in the posterior region of the dental arches after the six months period and particularly so in the mandibular arch.

The observed growth changes in the dental arches appear to be associated with the eruption of the deciduous teeth.

TABLE OF CONTENTS

	Page
Title Page	i
Approval Sheet.	ii
Abstract	iii
Acknowledgements	v
Table of Contents	vi
List of Tables.	viii
List of Illustrations	xi
INTRODUCTION.	1
REVIEW OF THE LITERATURE	
I Growth of the Jaws and Their Relationship During Growth	2
II Eruption of Deciduous Teeth	30
AIMS OF THE STUDY.. . . .	34
METHOD	
A Material.	34
1. Number and Source of Cases Studied.	34
2. Technique of Obtaining Records.	35
a. Bite Relation	35
b. Impression.	38
c. Casts	39
B Measurements	42
1. Points of Reference	42
a. Growth Reference Points	42
b. Occlusion Relation Reference	45

ACKNOWLEDGEMENTS

I wish to express my special thanks and appreciation to Dr. C. R. Castaldi for providing the opportunity and the facilities for carrying out this research under his guidance. His supervision and constructive criticism during the preparation of this manuscript is heartily acknowledged.

Appreciation is also extended to Dr. W. Zacherl for his assistance in recording and analyzing the data, and to Dr. G. H. Sperber for his assistance in establishing suitable reference points from which comparative measurements could be made.

I also thank Miss Margaret Law for her help in organizing the study, Mrs. Florence Gutteridge and Miss Margaret Law for assistance in obtaining the data, and Miss Brenda Lemke and Mrs. Marianne Orman for their patience and accuracy in the final typing.

Sincere appreciation is expressed to the Department of National Health and Welfare, Ottawa, Ontario for their financial support of this project, #608-7-65.

Finally, I wish to acknowledge the unyielding encouragement received from my wife, Lorna.

There appears to be little change in the height and width of the palatal vault during the first two years of life. In fact, palatal vault height appears to be established prior to age one.

At birth the mandibular arch is posterior to the maxillary arch when the gum pads are occluded. This posterior relation of the mandibular arch continually decreased with age to 21 months.

An anterior opening between the occluded gum was present in 71.5% of the cases studied and absent in the remaining 28.5%. The absence of the anterior opening may be a factor in the development of abnormal occlusion, and for this reason, it is important to follow-up the cases in the present study.

The eruption times of the deciduous teeth varied greatly, a finding which agrees with previous studies.

Incisal edges of newly erupted deciduous incisors tend to follow the curvatures of the anterior portions of the dental arches.

The spaces between maxillary deciduous teeth were found to be greater than the spaces between the mandibular deciduous teeth. In one-third of the cases studied, the mandibular deciduous central incisors were crowded.

The significance of the observed growth cannot be completely evaluated until further study has been made of subsequent changes in the dentition, which accompany increased age.

2. Methods of Measuring.	47
a. Dental Arch Growth.	47
b. Palatal Vault Growth.	52
c. Occlusal Relationship	54
d. Eruption of Teeth and Movement of Teeth after Eruption.	55
3. Recording of Data	56
RESULTS	
A Growth.	60
B Occlusal Relationship	87
C Eruption of Deciduous Teeth and Movement of Teeth after Eruption.	91
DISCUSSION	
A Changes in Dimension of the Maxillary and Mandibular Arches	98
B Changes in Dimension of the Palatal Vault	101
C Occlusal Relation of the Dental Arches.	103
D Eruption of Deciduous Teeth and Movement after Eruption.	105
SUMMARY AND CONCLUSION.	108
BIBLIOGRAPHY	112
OTHER READING	115

LIST OF TABLES

Table		Page
1.	The Average Dimensions of the Palate in the Newborn - Ashley Montagu, 1934.	8
2.	Anterior Curvatures of the Palate - Ashley Montagu, 1934	9
3.	Palatal Contour, Classified from Palatal Indices - Ashley Montagu, 1934.	9
4.	Palatal Contour, Classified from Palatal and Anterior Arch Indices - Ashley Montagu, 1934.. . . .	10
5.	Classification of Gum Pad Relationship - Clinch, 1934 .	14
6.	Types of Occlusion and Mean Measurements of the Characters - Clinch, 1934	16
7.	Distribution of Distal Relationship of the Gum Pads in the Newborn Infant - Sillman, 1938	19
8.	The Incidence of Habits in Bottle and Breast Fed Children - Heckmann, 1963	29
9.	Age of Eruption of the First Deciduous Tooth - Meredith, 1951	30
10.	Number of Erupted Deciduous Teeth at Selected Ages - Meredith, 1951	30
11.	Age at which Eruption of the Deciduous Dentition is Completed - Meredith, 1951.	31
12.	Age in Months of Eruption of the First and Last Tooth - Lysell, 1962.	32
13.	Age in Months of Eruption of the Various Teeth - Lysell, 1962	32
14.	Records of the Children Involved in this Study	36
15.	Growth Reference Points	44
16.	Occlusal Reference Points	45
17.	Growth Measurements	50
18.	Occlusal Relation Measurements.	54

19. Tabulation of Ridge Growth Measurements in Millimeters of Different Age Groups 61 - 71

1. Anterior Palatal Length

2. Maximum Palatal Length

3. Posterior Palatal Width

4. Anterior Palatal Width

5. Palatal Arch Length

6. Mandibular Mid-Line Length

7. Maximum Palatal Width

8. Posterior Mandibular Width

9. Anterior Mandibular Width

10. Mandibular Posterior Pad Width

11. Mandibular Arch Length

20. Tabulation of Palatal Vault Measurements of Different Age Groups 72 - 73

1. Palatal Vault Width at J.

2. Palatal Vault Width at K.

3. Palatal Vault Height at J.

4. Palatal Vault Height at K.

21. Mean Growth Measurements in Millimeters of Different Age Groups. 84 - 85

22. Mean Palatal Vault Measurements in Millimeters of Different Age Groups. 86

23. Occlusal Relation Measurements in the Anterior Area for Different Age Groups. 87

24. Occlusal Relation Measurements in the Canine Area for Different Age Groups. 88

25. Percentage Overbite for Different Age Groups 89

26. Mean Measurements of Occlusal Relation and Percentage Overbite 90

27. Incidence of Pre-Eruption Anterior Opening 89

28. Tabulated Measurements of the Angles of the Deciduous Incisors to the Mid-Line; Measured Within Six Months After Eruption. 92

29. Tabulated Measurements of the Distance Between the Deciduous Incisors and the Mid-Line; Measured Within Six Months After Eruption 93

30. Tabulated Measurements of the Space Between the Deciduous Teeth; Measured Within Six Months After Eruption 94

Table		Page
31.	Mean Angle of the Deciduous Incisors to the Mid-Line. .	95
32.	Mean Distance Between the Deciduous Incisors and the Mid-Line	95
33.	Mean Space Between the Deciduous Teeth	96
34.	Mean Eruption Times of the Deciduous Teeth Recorded in Months.	97

LIST OF ILLUSTRATIONS

Figure		Page
1.	Palatal Drawing - Ashley Montagu, 1934.	4
2.	Pantograph Tracing Showing Measurement Cords - Ashley Montagu, 1934.	7
3.	Palatal Contours - Ashley Montagu, 1934	10
4.	Mandibular Gum Pad - Clinch, 1934	12
5.	Drawings of Occlusal Classifications - Clinch, 1934 . .	13
6.	Drawings of Gum Pads Showing Reference Points - Clinch, 1934	17
7.	Occlusal Reference Points - Sillman, 1938	19
8.	Drawing of Maxillary Arch Showing Palatal Reference Points - Lebret, 1962	24
9.	Wax Bite	38
10.	The Position in Which Babies Were Held During the Taking of Impressions	40
11.	Acrylic Trays	40
12.	Dental Casts from a Series.	41
13.	Predentition Casts in Occlusion	42
14.	Reference Points	43
15.	Reference Points After the Eruption of Deciduous Teeth.	43
16.	Occlusal Reference Points	45
17.	Pantograph.	46
18.	Pantograph Tracing Showing Reference Points, Measurements, Cords, and Incisor Teeth	48
19.	Symmetrograph	51
20.	Palatal Reference Points	53
21.	Palatal Tracing Showing Measurement Cords	53
22.	Position of Deciduous Teeth	56
	1. Distance from Incisors to the Mid-Line	
	2. Angle of Incisors to the Mid-Line	
	3. Space between Adjacent Teeth	

INTRODUCTION

The phenomenon of growth no doubt has been of great interest to mankind for many centuries, but it has only been within the last two hundred years that any organized attempt has been made to study growth in any great detail.¹ Count Philibert Gueneau de Montheillard² carried out a study on his son from 1759 to 1777 and showed that the velocity of growth decreased from birth until almost twelve years of age when it began to increase until after age fourteen years, when the velocity again decreased. Since de Montheillard's time, a great deal of knowledge on growth and development has been uncovered; however, there is still much to be learned, particularly in dental development from birth to three years of age.³ Because of this need, the attention of this thesis has been focused on the growth of the jaws in children during the first two years of life. The location and rate of growth and the changing relationship of the jaws as they grow have been studied and recorded. As the deciduous teeth developed and erupted through the gum pads, their position and dates of eruption were observed. Attention was placed on the movement of the teeth after eruption and their relationship to each other.

An extensive review of the literature was undertaken. The pertinent information is being presented under two headings:

1. Growth of the Jaws and their Relationship During Growth
2. Eruption of the Deciduous Teeth

I. GROWTH OF THE JAWS AND THEIR RELATIONSHIP DURING GROWTH

West⁴ in 1925 examined human embryos and fetuses from the seventh to the fortieth week and observed the developing maxillary pad in relation to the deciduous tooth buds. He concluded that the gum pad develops in two parts: (1) the buccal-labial, (2) the lingual. The former forms most of the adult gum and during development becomes segmented. These segments correspond directly to the developing deciduous teeth and play a part in each tooth's development and eruption.

In 1926, Sheldon Friel said:

At birth their pads do not meet in the anterior region, as the tip of the tongue lies between the two pads. There is not much variation in the anteroposterior relationship of these pads, the lower seems to be as far forward as the upper pad, though in⁵ one case out of 12 the lower pad was in postnormal relationship.

In 1934, Ashley Montagu⁶ of New York presented an introductory report of the result of an investigation carried out on the palates of ninety newborn infants. The twofold objectives were:

1. To devise a valid method of measuring the palate
2. To study the form and dimension of the palate of the newborn.

He emphasized that this was a preliminary report and that a long-term controlled study of various age groups would be necessary for a thorough study of the form and dimensions of the palate.

Before presenting his own method and results, he discussed the general morphology of the fleshy and bony palate of the newborn, using skulls and prepared dissected sections. He found considerable difference in form, appearance and dimensions between the bony and fleshy palate as follows:

1. The posterior and posterolateral walls of the maxilla are slightly developed. However, there is a very definite posterior wall present in the fleshy palate.
2. The outline of the fleshy palate has the appearance of a rather broad horse shoe, being somewhat convergent at the posterior margins, whereas the bony palate has a divergence at the post alveolus¹¹ process. The depth of soft tissue to bony alveolus varied from 4.2 mm. in anterior to 2 mm. at post gingival, and 5 mm. at the molon point.

He presented a diagram of the palate of the newborn which described a series of landmarks (Fig. 1). These included:

- A. Post gingival
- B. Incisive point
- C. Lateral sulcus
- D. Posteriolateral sulcus
- E. Median palatine raphe
- F. Incisive papilla
- G. Alveolar palatine groove
- J. Anterior sulcus
- K. Anterior lateral sulcus

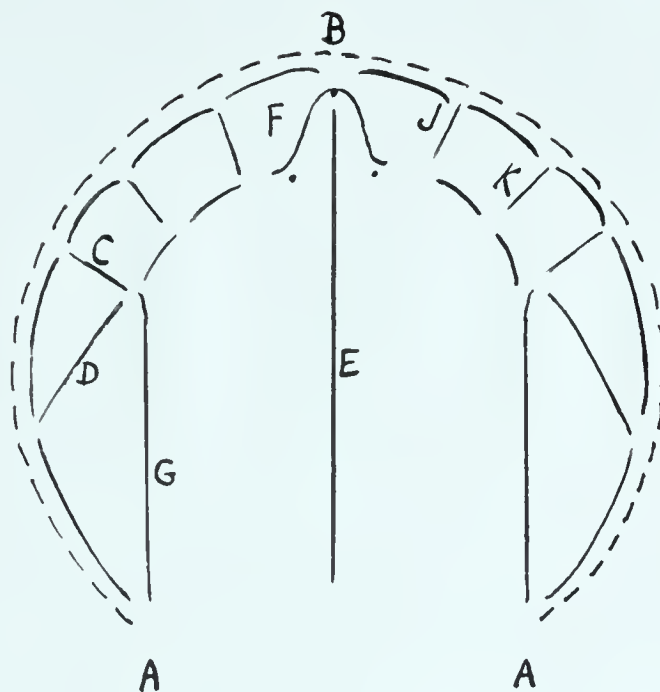


Fig. 1. Palatal Drawing
(Ashley Montagu, 1934)

It was noted, through dissection, that these sulci correspond exactly to the walls of the crypts that separate developing teeth, and to the diastema of the deciduous teeth as they lie in their crypts.

The dimensions of these crypts were as follows:

	<u>Length</u>	<u>Breadth</u>
Central Incisor	5.3 mm.	4.1 mm.
Lateral Incisor	5.2 mm.	4.0 mm.
Canine	4.0 mm.	3.5 mm.
First Molar	7.0 mm.	5.2 mm.
Second Molar	6.1 mm.	6.5 mm.
First Permanent Molar	31.7 mm.	29.2 mm.

The method used in his study consisted of impressions taken of ninety living newborn males, ranging between the ages of birth and thirteen days, with an average age of 3.7 days $\pm$ 2.8 days. The infants were all of normal form and structure and were representatives of the poorer class. The material used for the impression was modeling compound, with the casts being poured in dental stone. No details were given as to the exact technique; i.e. position of infant, use of trays, handling of material, etc. However, it was stated that the buccal surfaces and posterior margins of the gingiva were ill-defined in many cases. A measurement of the perfect cast was described in its entirety. First, the following points were marked on the cast in pencil: (A) Post gingival, (B) Incisive point, (G) Anterior lateral point, (L) Lateral sulcus point, and (M) Molon point. The cast was then placed upon a Stanton's dental pantograph and drawn to an enlarged scale of five times. The following cords were then projected and are illustrated in Fig. 2:

1. Maximum palatal breadth (D) = greatest diameter slightly posterior to molon point.
2. Posterior palatal breadth = diameter between posterior gingival points (A - A).
3. Anterior palatal breadth = diameter between lateral sulcus points.
4. Maximum palatal length = incisive point to posterior breadth cord (B - E).
5. Anterior palatal length = incisive point to anterior sulcus breadth cord.

6. Middle palatal length = from the point at which the palatal length cord bisects the anterior breadth cord to the corresponding point on the maximum breadth cord.
7. Posterior palatal length = point of bisection of the maximum breadth cord by the palatal length cord to the corresponding point on the posterior breadth cord.
8. Palatal height = maximum height above occlusal surface of gingivum.
9. Locus of maximum palatal height point from incisive point to maximum.
10. Distance of maximum palatal height point from palatal length cord.
11. Distance of maximum palatal height from maximum breadth cord.
- 12 & 13. Lateral incisive cord. Incisive point to lateral sulcus point right and left.

He also calculated the following indices:

- | | | |
|--------------------------------|---|---|
| 1. Palatal index | = | $\frac{\text{maximum palatal breadth} \times 100}{\text{maximum palatal length}}$ |
| 2. Palatal height index | = | $\frac{\text{maximum palatal height} \times 100}{\text{maximum palatal breadth}}$ |
| 3. Anterior palatal arch index | = | $\frac{\text{anterior palatal length} \times 100}{\text{anterior palatal breadth}}$ |

TABLE I

THE AVERAGE DIMENSIONS OF THE PALATE IN THE NEWBORN

(Ashley Montagu, 1934)

Number of Cases from which Calculated	Character	Average Value	Standard Deviation
78	Age in days	3.7	$\pm$ 2.8
90	Body weight in grams	3,315.0	$\pm$ 539.5
78	Sitting height	332.0	$\pm$ 17.6
78	Nasion Prosthion height	31.0	$\pm$ 1.4
82	Anterior palatal breadth	25.5	$\pm$ 1.5
90	Maximum palatal breadth	30.6	$\pm$ 1.5
90	Posterior palatal breadth	25.5	$\pm$ 1.2
90	Maximum palatal length	25.6	$\pm$ 1.6
82	Anterior palatal length	6.9	$\pm$ 2.5
82	Middle palatal length	7.4	$\pm$ 2.9
82	Posterior palatal length	11.3	$\pm$ 2.8
90	Distance of maximum palatal breadth cord from incisivum	14.3	$\pm$ 1.3
90	Palatal height	7.6	$\pm$ 2.0
90	Distance of maximum palatal height point from incisivum	15.1	$\pm$ 2.1
82	Distance of lateral sulcus point from incisivum: Right side	14.4	$\pm$ 1.1
	Left side	14.4	$\pm$ 1.1
90	Palatal index	119.9	$\pm$ 6.7
90	Palatal height index	24.8	$\pm$ 2.3
83	Anterior palatal arch index	27.4	$\pm$ 3.6

Measured in mm.

From the anterior palatal indices he classified the anterior curvatures of the palate into five types (Table 2).

TABLE 2
ANTERIOR CURVATURE OF THE PALATE
(Ashley Montagu, 1934)

Index	Type	Name	Number
20.0 - 23.0	Flat or blunt	Platyform	10
23.1 - 26.0	Not as flat	Mesiform	19
26.1 - 30.0	Arc of a circle	Cycloform	33
30.0 - 33.0	Sharper than cycloform	Propyriform	15
33.1 - 37.0	Pointed	Pyriform	6

Average Index: $27.4 \pm 3.6 = \text{cycloform}$

From the palatal indices he classified the palatal contour into four types (Table 3).

TABLE 3
PALATAL CONTOUR, CLASSIFIED FROM PALATAL INDICES
(Ashley Montagu, 1934)

Name	Index	Number	Type
1. Dolichouranic	100 - 110	8	Long
2. Mesuranic	110 - 120	36	Fairly broad
3. Brachyuranic	120 - 130	37	Very broad
4. Hyperbrachyuranic	130 - 140	2	Excessively broad

Average Index: $119.9 \pm .67 = \text{brachyuranic}$

The anterior arch and palatal indices were then combined. The resulting contours are diagrammed in Fig. 3 and listed in Table 4. It was noted that the long palate tends to have a sharp anterior curvature, while the broad palate tends to have a flatter anterior curvature.

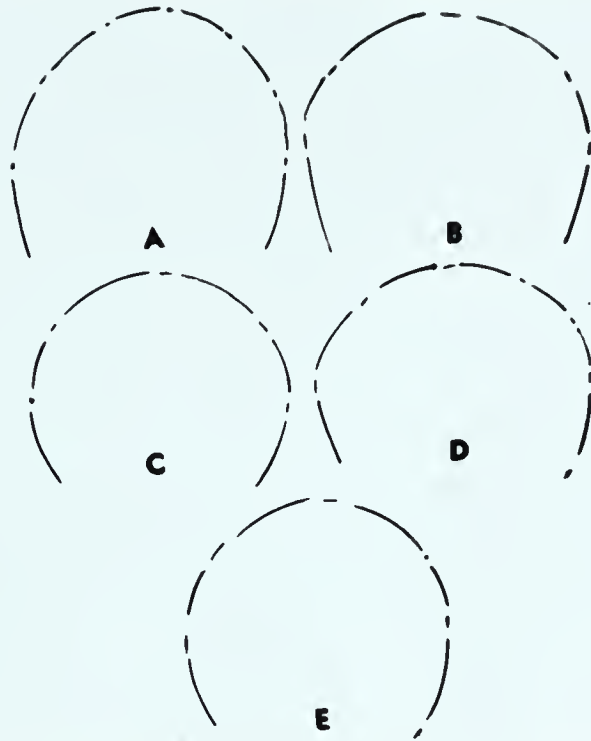


Fig. 3. Palatal Contours
(Ashley Montagu, 1934)

TABLE 4

PALATAL CONTOUR, CLASSIFIED FROM PALATAL AND
ANTERIOR ARCH INDICES

(Ashley Montagu, 1934)

No.		Palatal Index	Anterior Arch Index
A.	75	Dolichouranic	Pyriform
B.	85	Brachyuranic	Mesiform
C.	18	Brachyuranic	Cycloform
D.	82	Hyperbrachyuranic	Platyform
E.	32	Mesuranic	Propyriform

Ashley Montagu found that his findings were similar to those of Alkan⁷, Denger⁸, Katz⁹, Payton¹⁰, and Frank¹¹.

In 1934, Lila Clinch¹² of England presented a paper based on her study of the form and relationship of the gum pads in living newborn infants.

Preliminary: 100 newborn infants were examined and the following characteristics observed:

1. Appearance of gum pads
2. Precautions necessary in approximating the gum pads accurately
3. Relationship of maxillary gum pads to mandibular gum pads

Seventy sets of impressions were then taken using "Nadray" impression compound preheated in boiling water. The trays were made of thin aluminium, previously modified when adapted to fit the mouth of six-month-old infants. When taking the maxillary impression, no material was placed on the palatal portion of the tray; however, in most cases, a satisfactory impression of the palate was obtained. The operator stood in front of the patient while taking all impressions. No bite relationship was taken. The author noted:

1. The presence or absence of space in the incisor region, and if present, the limits of space on each side of the maxilla and in the mandible.
2. The relation of the anterior margin of the first molar segment of the mandible to that of the maxilla.

The maxillary gum pad was then described, using a diagram by West⁴ to illustrate the landmarks. These were similar to those described by Montagu⁶, though not as detailed. The mandibular gum pad was also described (Fig. 4). Being more U-shaped, it was divided into an anterior

and two lateral parts; the anterior part being formed by the four incisor segments, the lateral parts by the molar segments. The canine segment lay in the angle between the two parts. She found the anterior part comparatively broad and sometimes inverted in front, while each lateral part had a narrow edge and was raised above the level of the anterior part. The gum was firm, as in the maxilla, except for the inverted incisor area when present (Fig. 4).



Fig. 4. Mandibular Gum Pad
(Clinch, 1934)

Findings.--Relation of Mandibular to Maxillary Gum Pads (Clinch, 1934)

From a total of 400 children examined, the gum relationship was classified into three main classes (Table 5). Drawings of each type are presented in Fig. 5.



1(a)



1(b)



2(a)



2(b)



3

Fig. 5. Drawings of Occlusal Classifications
(Clinch, 1934)

TABLE 5

CLASSIFICATION OF GUM PAD RELATIONSHIP

(Clinch, 1934)

Class	Sub-Class	Description	No.	% in Class	%
1	a	Mandibular arch slightly lingual to maxillary arch in incisor and molar regions plus anterior space	24	73	Total 70
	b	Same as 1a except no anterior space	76	27	
		Total:	280	100	
2	a	Mandibular arch slightly lingual and distal to maxillary arch in molar region, but definitely distal in incisor area	46	42	27
	b	Same as 2a except no anterior space	62	58	
		Total:	108	100	
3		Mandibular arch definitely lingual and distal to maxillary arch in both molar and incisor regions. Thus, no vertical space	12	100	3

Clinch noticed that the molar segments were always in contact but this was not the case in the anterior region where in 62% of the cases, the gum pads were not in contact. She believed this space was present to permit the eruption of the incisor teeth. She also believed that the degree of overbite depended upon the presence or absence of vertical space in the incisor region. It is of interest that no cases of mandibular protrusion were found. Some measurements were taken from well defined points (Fig. 6). (A description of these measurements is as follows:)

Maxilla:

Characters.

1. Depth of palate
2. Length of arch 2 - 2
3. Breadth at distal of canine 3 - 3
4. Breadth at widest portion 4 - 4

Mandible:

Characters.

5. Length of mandibular arch
6. Breadth of arch at distal of canine 6 - 6
7. Breadth of arch at widest portion 7 - 7

A comparison of these measurements with the different types of occlusion is presented in Table 6.

TABLE 6

TYPES OF OCCLUSION AND MEAN MEASUREMENTS OF THE CHARACTERS*

(Clinch, 1934)

TYPES	CHARACTERS						
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
1A	7.42 (19)	21.06 (19)	25.58 (19)	31.21 (19)	17.43 (19)	21.79 (19)	26.37 (19)
1B	6.73 (13)	20.84 (12)	24.62 (13)	30.00 (13)	18.53 (12)	21.54 (13)	25.62 (13)
2A	7.15 (13)	21.82 (12)	<u>25.38</u> (13) *	29.77 (13)	16.94 (12)	<u>23.23</u> (13) *	26.77 (13)
2B	8.04 (12)	21.28 (8)	<u>23.50</u> (12)	29.83 (12)	15.48 (8)	<u>21.33</u> (12)	25.67 (12)
1 (A+B)	7.14 (32)	20.98 (31)	25.19 (32)	30.72 (32)	<u>17.90</u> (31)*	21.69 (32)	26.06 (32)
2 (A+B)	7.58 (25)	21.60 (20)	24.48 (25)	29.80 (25)	<u>16.31</u> (20)	22.32 (25)	26.24 (25)
A (1+2)	7.31 (32)	21.35 (31)	<u>25.50</u> (32)*	30.69 (32)	17.24 (31)	22.38 (32)	26.53 (32)
B (1+2)	7.36 (25)	21.02 (20)	<u>24.08</u> (25)	29.92 (25)	17.48 (20)	21.44 (25)	25.64 (25)
3	8.75 (4)	20.50 (1)	24.00 (4)	29.50 (4)	16.00 (1)	19.50 (4)	22.75 (4)

* Only those means which are underlined can be considered to differ to a significant degree in the number available.



Fig. 6. Drawings of Gum Pads showing
Reference Points
(Clinch, 1934)

In 1935, Goldstein and Stanton¹³ of New York measured growth changes on 546 sets of casts representing 300 children between one and eleven years. The impressions were taken with modelling compound. Stanton's pantograph¹⁴ was used to project magnified drawings of the casts. Few impressions were taken of children less than two years old. Measurements were made between the centers of corresponding teeth, right and left for width; and from between the central incisors, point "Y", to the mid-point of a line joining the distal of right and left second deciduous molars, Point "Y", for length.

Findings.-- Measured in millimeters

1. Width from 2 - 9 years

	<u>Maxillary</u>	<u>Mandibular</u>
(1) Canines	2.5 increase	2.5 increase
(2) First Molar	2.1 increase	2.7 increase
(3) Second Molar	2.1 increase	1.8 increase

2. Length (Y - Y') from 2 - 5 years

Maxilla - decrease of 1 mm.

Mandible - decrease of .8 mm.

A sex difference was noted in all measurements, with males having larger arches, and greater fluctuation in growth.

J. H. Sillman, New York.--In 1938, J. H. Sillman¹⁵ of New York published a paper on the relationship of the maxillary and mandibular gum pads in the newborn infant. A few trial impressions were taken using soft metal trays and compound. From these stone models, better adapted trays were prepared and used for further impressions. After various procedures, he found the most accurate method of obtaining a relationship of the gum pads was by means of a bite, consisting of a piece of tray metal sandwiched between two sheets of beeswax. The relationship was taken with the baby in the supine position and in the state of repose. In 20 cases, a duplicate bite was taken to assess the accuracy; result - 9 the same, 9 with a difference of 1 mm., and 2 with a difference of 2 mm. A total of 134 bites were taken. The total number of casts obtained was not given. However, a total of 709 infants were observed.

His description of the anatomy of the gum pads was similar to that of Clinch¹² and others^{4, 6}.

Method and Results.--Two anteroposterior dimensions were taken in order to evaluate the relationship of the gum pads:

1. The distance between the maxillary and mandibular lateral sulci.
2. The distance between the most anterior point of the maxillary and mandibular arches. These dimensions (Fig. 7) were read to the nearest millimeter with a Vernier caliper and are presented in Table 7.

TABLE 7

DISTRIBUTION OF DISTAL RELATIONSHIP OF THE
GUM PADS IN THE NEWBORN INFANT

(Sillman, 1938)

	Sex	Mean	Characters A + B (mm)								
			0	1	2	3	4	5	6	7	8
For Character A	♂	2.7	1	6	13	12	7	6	1		
	♀	2.5	6	7	14	11	7	3	1	1	
For Character B	♂	4.5			2	5	17	5	7	7	1
	♀	4.1			5	11	18	7	4	3	1

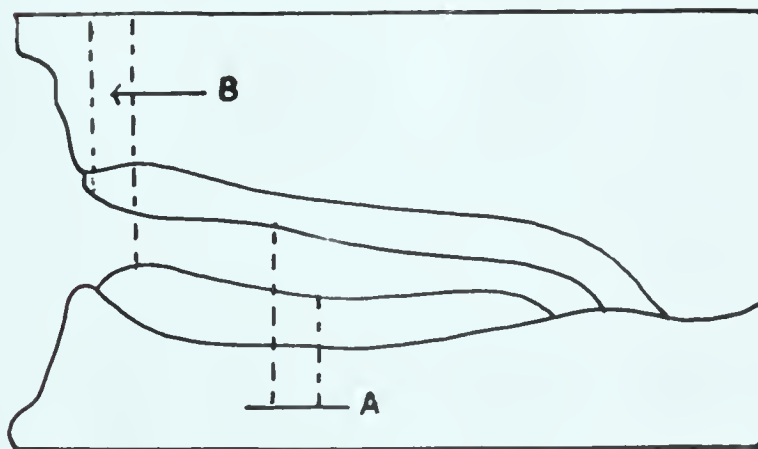


Fig. 7. Occlusal Reference Points
(Sillman, 1938)

He stated that the possibility of opening the bite and displacing the mandible distally is most unlikely in taking the bite relation. The mandible, displaced by the child or the operator, would be either open or to the mesial. In spite of this possibility the mean distal relationship of the mandible to the maxilla measured at B on the casts was 4.5 mm. in males and 4.1 mm. in females, with a range of 2 - 8 mm.

From his observations, Sillman concluded that when the jaws are at rest, the gum pads do not meet. He further observed that the anterior space between the gum pads varied in form. These spaces, he classified as follows:

Class A. The maxillary and mandibular anterior segments are in parallel planes.

Class B. In the maxillary pad, the incisal segments are higher than the canine segments, while in the mandibular pad, the anterior segments are in the same plane.

Class C. In the maxillary pad the incisal segments are higher than the canine segments while in the mandibular pad the canine segments are higher.

Class D. In the maxillary pad the anterior segments are in the same plane, while in the mandibular pad the canine segments are higher.

He believed these variations to be associated with varying positions of the tooth sacs.

Measurements were made on the cast with a Vernier caliper, measuring to the nearest tenth of a millimeter. Seven measurements were taken on the maxillary pad and five on the mandibular pad. These were then compared with those made by Clinch¹² and Bakwin¹⁶. In most instances

the differences were believed to be within the normal range of error, except for character 3 and possibly character 6. No statistics were offered.

Other conclusions were:

1. There is limited anteroposterior movement of the mandible but no lateral movement.
2. When the jaws are at rest, the gum pads do not meet.
3. The space between the anterior segments of the gum pads varies in form.
4. With an increased distal relationship of the jaws, the dimensions of the mandibular gum pads seem to be affected. The length and anterior width show an increase, while the posterior width shows a decrease.

In 1940, Clinch¹⁷ presented a serial study on the occlusal relationship of the maxilla and mandible. Only two cases were studied, each having three sets of models. The ages at which the impressions were taken are as follows:

<u>Case I</u>	<u>Case II</u>
1 year 6 months	2 years 0 months
2 years 9 months	2 years 10 months
4 years 0 months	3 years 6 months

After examining several fetuses and the dental casts of this study, Clinch concluded that the relationship of the arches is constantly changing during the fetal period and during the first four years of life. She further concluded that any gross disproportion at birth, such as a 7 mm. maxillary overjet, would correct itself through growth, unless mechanically prevented, (i.e. habits, injuries, etc.). However, she did not

believe that the absence of a vertical opening in the incisor area would correct itself. In fact, she believed that lack of vertical opening would interfere with the forward growth of the mandibular arch, because the maxillary anterior gum pad would overlap the mandibular anterior gum pad.

Sillman¹⁸, 1945, reported a serial study of growth of the jaws from birth to seven years of age. Forty children were involved, with the number of articulated casts in each series varying from four to twenty four. He discussed with illustrations the variations in the anterior opening of infant's gum pads, and concluded from his study that this opening is not a factor in the development of normal occlusion. Among his illustrations were casts of two children before and after the eruption of the deciduous teeth, in which it was noted that a normal occlusion developed in spite of an extensive maxillary overjet.

Further conclusions were as follows:

1. There is no occlusion at birth.
2. There is a protrusive occlusion prior to the eruption of the incisors and lateral occlusion prior to eruption of the first molars.
3. Centric occlusion is first established when all the first deciduous first molars have erupted.
4. Malocclusion may be prognosticated with the eruption of the first deciduous molars.

In 1961, J. K. Bambha¹⁹ of Denver, Colorado, reported on the growth of the face and cranium of pre-school children. Seven cranial and facial measurements were made on a series of cephalometric radiographs taken of fifteen boys and fifteen girls. The first cephalometric radiograph was taken when the children were one month of age, the second

at nine months of age, and the five succeeding ones at yearly intervals. Facial growth was rapid for the full five years, with the greatest rate in the first two years of life. Boys had a faster growth rate than girls and was demonstrated very early.

In 1962, Lebret²⁰ of Forsyth Dental Infirmary, Boston, Massachusetts, reported on the growth of the palate from five to eighteen years of age. His material consisted of a series of dental casts of thirty individuals, with five casts to each series. Measurements were made by using a modified Korkhaus²¹ symmetrograph. The casts were similarly orientated so that each succeeding palatal contour would originate from the same point (Fig. 8). On the first cast of each series a line was drawn connecting the distal limits of the second deciduous molars. Where this line crossed the median raphe, point A was marked. Point R was then marked on a clearly defined ruga and projected to the mid-line R'. The distance from R' to A was noted and recorded. Other points on the rugae (X,Y,Z) were also marked and their distance from A recorded. In the remaining cast of each series, point A was located by measuring back from point R' and X, Y, Z. Lateral palatal contours were traced through point A and ten millimeters anterior to A (point B). The tracings terminated at the gingival margin of the teeth. A mid-line tracing passing through points A and B was also recorded for each model in each series.

He found the following:

1. No growth changes occurred at the apex of the vault of the palate.
2. There was a 1 - 2.5 mm. growth increment in the middle of the vault of the palate.
3. The increase at the vault of the palate exceeded 2.5 mm.

4. There was a mean increase in palatal height of 3.6 mm. This was thought due to alveolar growth, as the palatal vault height did not change.
5. There was a mean increase in palatal breadth at point A of 4.0 mm. which was made up of 1.9 mm. from palatal vault growth and 2.1 mm. from alveolar process growth. There was 3.0 mm. increase at point B which included .9 mm. from the vault and 2.1 mm. from the alveolar ridges.
6. The mid-sagittal outline comparisons indicated a downward and forward growth of the alveolar process in the incisor region.
7. Variation in symmetry was slight and within the range of error.

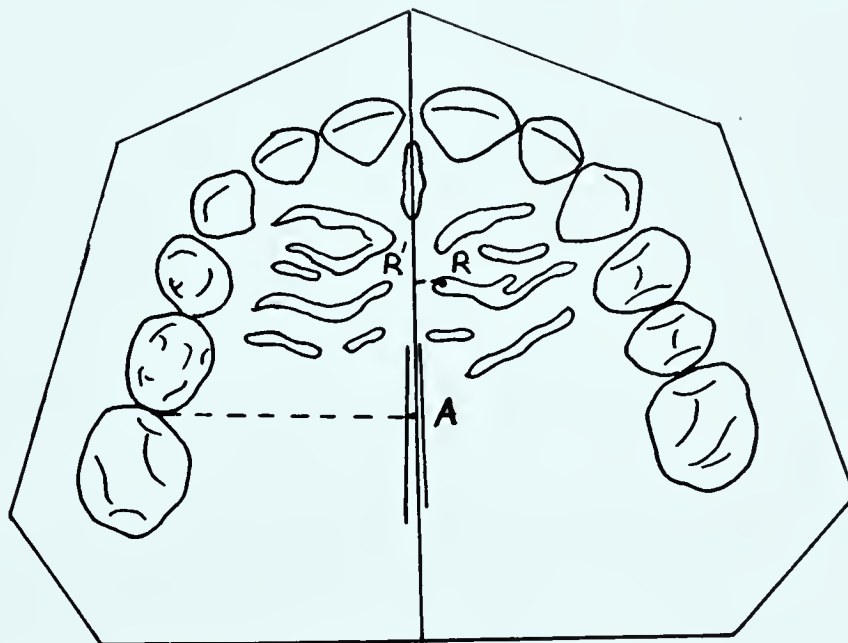


Fig. 8. Drawing of Maxillary Arch Showing Palatal Reference Points

(Lebret, 1962)

He concluded:

The alveolar processes increased in height and breadth continuously. The shape of the top of the palatal vault remained essentially constant except for an increment in breadth at the apex of the palatal vault in three-fourths of the sample. It was not possible to define whether this increment was due to growth at the mid-palatal suture, to bone remodeling, or to the association of both.²⁰

Moorrees²², 1959, completed a detailed longitudinal study of dental development in 184 North American white children between three and eighteen years of age. In his review of the literature, he noted general agreement by most authors on the following:

1. Maxillary arch length increases slightly but the mandibular arch length decreases.
2. Palatal height increases.
3. Arch breadth in both jaws increases, greater in the maxilla.

The greatest increase occurred during the eruption of the permanent incisors and canines.

Material.--The impression materials used were modeling compound and hydrocolloids. Several dentists participated in gathering the material for the study. Features studied included: spacing, crowding, maxillary arch form, occlusion, transverse distance, position of planes, degree of overlapping and eruption times. Average tooth size and arch length and breadth were also recorded. He concluded that, due to large individual variations, dental changes could not be predicted at a young age. However, the presence of longitudinal records will increase accuracy in predictions. Regarding the commencement of orthodontic treatment, he concluded that the individual child is seldom average and this requires highly individual considerations. He noted that children with broad deciduous teeth are likely to have broad permanent teeth and, similarly, children with a narrow deciduous arch tend to have a narrow arch when adults.

Sillman²³, 1964, reported on a longitudinal study of the dimensional changes of the dental arches. Seven hundred and fifty dental casts were obtained from sixty-five normal white individuals. The time spanned from birth to twenty-five years of age. There were thirty-eight sets of casts for each age group and an average of twelve casts for each individual. All but twelve cases were followed for more than fifteen years. The time interval between impressions was not stated. For the first eight years of the study, modeling compound was used as the impression material; hydrocolloid or alginate was used thereafter.

Measuring points:

The points of reference are as follows:

Point I	Approximates the crest of the interdental septum between the deciduous central incisors.
Point II	The distal wall of the canine alveolus.
Point III	Distal aspect of the erupted second deciduous molar.
Point IV	Approximates the dental aspect of the alveolus of the second deciduous molar.
Point R	Two distinct ruga points on each side of the palate near the gingival groove.

Points I, II, and IV were established after a careful dissection was made of the maxillary and mandibular gum pads of a stillborn infant.

Findings:

1. CANINE LENGTH (Point "I" to the middle of a line joining the right and left "II" points).

(a) Males.--In both arches, the greatest increase was from birth to two years of age. From two to six years, there was little increase, followed by a significant increase up to nine years in the maxilla and ten years in the mandible. Past ten years, there was no significant change.

- (b) Females.--The findings were the same except in the mandible, where the significant increase ran from six to nine years.

2. MOLAR LENGTH (Point "I" to the middle of a line joining the right and left "III" points).

- (a) Males.--From three years to the third molar stage, there was a decrease in molar length, 1.5 mm. in the maxilla and 2.0 mm. in the mandible. The maxilla did show a period of increase from six to nine years.

- (b) Females.--The findings were the same, except the decrease continued beyond seventeen years.

3. TOTAL LENGTH (Point "I" to the middle of a line joining the right and left "IV" points).

- (a) Males.--From birth on there was a considerable increase in the total, with the greatest increase occurring from birth to three years of age (approximately 3 mm. per year). After the eruption of the second permanent molar, the increase was 0.3 to 0.4 mm. per year.

- (b) Females.--The findings were the same, except there was no significant increase after thirteen years of age.

4. CANINE WIDTH

- (a) Males.--Canine width increased from birth to about twelve to thirteen years of age, then leveled off. The greatest increase took place from birth to two years (5 mm. in the maxilla and 3.5 mm. in the mandible.)

- (b) Females.--The findings were the same, except there was no evidence of growth from sixteen years to the last age group.

5. MOLAR WIDTH

- (a) Males.-- Both arches showed a gradual increase up to the second molar stage, then a leveling off.
- (b) Females.--The findings were the same.

6. POSTERIOR WIDTH

- (a) Males.--Posterior width increased continuously in both jaws, with the greatest increase from birth to five years.
- (b) Females.--The findings showed a similar pattern, but with more irregularities.

Generally, it was observed that the arch increase preceded the eruption of a group of teeth. These groups, or stages, were deciduous teeth, first permanent molars and incisors, premolars and second molars and third molars. The greatest increase was in total length and posterior width.

Ruga Dimensions.--Due to variation in location, only the increases in dimension were considered.

Length.--The rate of increase was not uniform, the greatest increase occurring between the different stages (deciduous teeth, first molars, etc.).

Width.--There was no uniformity in the rate of increase. However, the greatest increase tended to occur between the different stages.

Heckmann²⁴, 1963, studied the development of the deciduous dentition in bottle and breast fed children. Impressions were taken at six-month intervals of 102 children. The first impressions were taken shortly after birth, and the last at the age of 2½ years. The casts were then examined and measured to see if the type of feeding had any effect on the development of the maxillary and mandibular dental arches.

Results showed that the type of feeding had no effect upon the maxillary and mandibular maximum width measured between the crest of the ridges.

It was also found that there was no relationship between the method of feeding and: (1) occlusion, (2) the incidence of habits. (See Table 8).

TABLE 8

THE INCIDENCE OF HABITS IN BOTTLE AND BREAST FED CHILDREN

(Heckman, 1963)

	No.	Mouth Breathers	Suckers	Non-Suckers
Breast Fed	36	1	31	4
Bottle Fed	66	1	58	7
Total	102	2	89	11

II. ERUPTION OF DECIDUOUS TEETH

The actual process of eruption is not understood although a number of theories have been advanced. (See Other Reading 10 & 18, page 115). No attempt was made in this study to evaluate the various theories nor to suggest new ones. The major interest was the time of eruption of the deciduous teeth and movement of these teeth after eruption.

Meredith (1946)²⁵ and (1951)²⁶ reviewed the literature on the order and eruption time of the deciduous teeth. Twenty-three studies involving a total of 1,095 children were summarized.

TABLE 9
AGE OF ERUPTION OF THE FIRST DECIDUOUS TOOTH
(Meredith, 1951)

Number	Mean Postnatal Age	Zone for 98%	Range
1095	7.5 months	4 - 12 months	0 - 16 months

In 95% of the cases the first tooth to erupt was a mandibular central incisor.

TABLE 10
NUMBER OF ERUPTED DECIDUOUS TEETH AT SELECTED AGES
(Meredith, 1951)

Postnatal Age	Number of Subjects	Mean Number of Teeth	50 Per cent	Zones for 98 Per cent	Range
9 months	670	3	2 to 5	0 to 8	0 to 12
12 months	700	6	4 to 8	1 to 11	0 to 20
18 months	500	13	10 to 14	6 to 18	4 to 20
24 months	510	17	15 to 18	10 to 19	8 to 20

TABLE 11

AGE AT WHICH ERUPTION OF THE DECIDUOUS DENTITION IS COMPLETED
(Meredith, 1951)

Number of Subjects	Mean Postnatal Age	Zone for 98%	Range
226	28 months	18 to 36 mo.	10 to 38 mo.

A sex difference in eruption time was noted with the male eruption time preceding the female by two weeks. The mean order of eruption was found to be:

lower central incisor
upper central incisor
upper lateral incisor
lower lateral incisor
first molars (upper and lower)
canines (upper and lower)
lower second molar
upper second molar

Lysell²⁷ and co-workers, 1962, presented a longitudinal study on the eruption of the primary teeth in 171 Swedish children, ninety-six boys and seventy-five girls. Each child was examined initially at three months of age, and at one-month intervals thereafter, until all the deciduous teeth had erupted. A tooth was considered erupted when any portion had broken through the gingiva. (See Tables 12 and 13).

TABLE 12

AGE IN MONTHS OF ERUPTION OF THE FIRST AND LAST TOOTH

(Lysell, 1962)

	Boys	Girls
First tooth	7.63 $\pm$.18	8.00 $\pm$.25
Last tooth	29.82 $\pm$.44	30.08 $\pm$.42

TABLE 13

AGE IN MONTHS OF ERUPTION OF THE VARIOUS TEETH

(Lysell, 1962)

TOOTH	Mean Age for Each Pair	
	Boys	Girls
Lower medial incisor	7.88 $\pm$ 0.19	8.20 $\pm$ 0.26
Upper medial incisor	10.01 $\pm$ 0.17	10.47 $\pm$ 0.21
Lower lateral incisor	13.23 $\pm$ 0.29	13.00 $\pm$ 0.37
Upper lateral incisor	11.20 $\pm$ 0.23	11.55 $\pm$ 0.27
Lower canine	19.92 $\pm$ 0.34	19.47 $\pm$ 0.35
Upper canine	19.30 $\pm$ 0.31	19.18 $\pm$ 0.33
Lower first molar	16.39 $\pm$ 0.23	16.12 $\pm$ 0.24
Upper first molar	16.08 $\pm$ 0.25	15.93 $\pm$ 0.22
Lower second molar	27.14 $\pm$ 0.40	27.07 $\pm$ 0.34
Upper second molar	28.89 $\pm$ 0.42	29.35 $\pm$ 0.41

The mean time from the first eruption to the last eruption was 22.20 months for boys and 22.08 months for girls. This total time was roughly equal whether the first tooth erupted early or late. It was also noted that those children whose first tooth erupted early did

not necessarily have a full complement of teeth early.

With the exception of the lower canine, the teeth on the left side erupted before the corresponding teeth on the right. For several teeth, the difference was significant at the 5% level.

Using mean time of eruption, the following order of eruption was calculated.

Upper jaw	A	B	D	C	E
Lower jaw	A	B	D	CE	

Three fairly marked stages of eruption were noted; the first consisting of the incisors; the second, the first molars and cuspids; and the third, the second molars. There was considerable individual variation. The mean order in the maxilla occurred in 52% of the cases, and in the mandible, 84%. However, when considering both upper and lower teeth, in only 5% of the cases studied did the eruption order follow the mean order. No variation due to sex was observed.

My review of the literature indicates that considerable information has been gathered on the form and dimensions of the dental arches in the newborn. Also, fairly extensive serial studies have been done on the development of the dentition from age three to eighteen. However, there are few serial studies on dental development from birth to age three. None of these have included the eruption and movement of teeth which occur simultaneously with ridge growth and changes in the occlusal relation of the arches. Sillman's²³ recent report is quite detailed, yet his observations are made only at yearly intervals. A comprehensive study of dental growth and development during the first few years of life requires more frequent and detailed records. It has been the aim of the present study to obtain and analyze such detailed records to increase our knowledge of dental development in the early age period. Such knowledge may assist in earlier diagnosis and prevention of complex malocclusions which are seen in the deciduous dentition, many of which are believed to be untreatable until a much later age.

THE AIMS OF THE STUDY ARE:

1. To observe and record changes in dimension, due to growth, in the maxillary and mandibular dental arches, from pre-dentition age to two years of age.
2. To study the jaw relation before eruption of the deciduous teeth and to observe any alteration during eruption.
3. To study and record the eruption time of the deciduous teeth and any movement of these teeth after eruption.

METHOD

A. Material

A series of maxillary and mandibular dental casts were obtained from children at six-month intervals. The first sets were taken when the children were about five months of age, with a range of one day to eight months. The casts were articulated with a wax bite.

1. Number and Source of Children

Thirty-eight children were involved in this study. Of the thirty-eight, twenty-one were the children of dentists or dental students; six were the children of other university students; and the remaining eleven were from outside the university. Records were taken as to race, sex, birth weight, birth history, and whether the child was bottle or breast fed. (Table 14).

Some totals from Table 14 are as follows:

Pairs of casts used in this study.	110
Sex: Male. 18; Female.	20

Type of feeding for more than two months:

Breast: Yes. 14; No. 24

Bottle: Yes. 29; No. 9

2. Technique

(a) Bite Relation.--For edentulous children, a bite fork was made from a piece of .030 orthodontic wire, adapted to fit a previously obtained cast of a child of approximately the same age. Two thicknesses of medium soft wax were adapted to the ridge portion of the fork (Dr. George S. Monson's Wax Bite Patterns). The wax was softened in hot tap water. Then, with the child on his back upon a pillow, the bite fork and softened wax were placed in the child's mouth against the maxillary gum pad. While it was held in place with the left hand, the right hand closed the mandibular gum pad into the wax. The wax bite (Fig. 9) was removed gently after a few seconds and placed in cool water. During this procedure and all others, the child was held by an assistant.

For older children with several fully erupted teeth, the same procedure was followed except a single sheet of thick soft wax was used in place of the bite fork, (Dr. Monson's Wax Bite Patterns). To test the accuracy of the wax bite, a visual examination of the occlusion was conducted and recorded. A comparison was later made. Suitable wax bites were not obtained for all sets of casts, as the described procedure for obtaining the bite was not perfected prior to the commencement of the study.

TABLE 14

RECORDS OF THE CHILDREN INVOLVED IN THIS STUDY

Number	Birth Date Day Month Year	Sex	Birth Weight	Feeding		Race		Age at First Impression	Casts θ
				Breast	Bottle	Mother	Father		
1	9 / 6 / 63	M	6-12	Yes	No	Caucasian	Caucasian	4½ months	3
2	11 / 7 / 63	M	7-12	No	Yes	"	"	3½ months	3
3	9 / 4 / 63	F	8-7	Yes	No	"	"	6 months	3
4	2 / 5 / 63	M	7-10	No	Yes	"	"	6 months	3
5	2 / 6 / 63	F	8-4	No	Yes	"	"	5 months	3
6	29 / 5 / 63	F	7-2	No	Yes	"	"	5½ months	3
7	27 / 7 / 63	F	8-9	No	Yes	"	"	3½ months	3
8	1 / 6 / 63	M	7-4	Yes	No	"	"	5½ months	3
9	3 / 2 / 63	F	7-3	No	Yes	"	"	9½ months	3
10	16 / 6 / 63	F	6-8	No	Yes	Negro	"	5 months	3
11	7 / 8 / 63	F	7-2	No	Yes	Caucasian	"	3½ months	3
12	19 / 8 / 63	F	7-7	No	Yes	"	"	3½ months	3
13	17 / 3 / 63	F	7-3	Yes	Yes	"	"	8½ months	3
*14	2 / 7 / 63	F	7-2	No	Yes	"	"	5 months	*1
15	22 / 9 / 63	M	9-1	No	Yes	"	"	5½ months	3
16	30 / 5 / 63	M	7-1	No	Yes	"	"	6½ months	3
17	20 / 6 / 63	M	8-4	No	Yes	"	"	6½ months	3
18	21 / 8 / 63	M	7-9	No	Yes	"	"	4½ months	2

TABLE 14, CONTINUED

19	22	/ 9	/ 63	F	7-2	Yes	Yes	Caucasian	Caucasian	4 months	3
20	?	/ 6	/ 63	F	6-10	Yes	Yes	"	"	7½ months	3
21	3	/ 10	/ 63	M	6-9	No	Yes	"	Chinese	4½ months	3
22	23	/ 10	/ 63	F	7-8	No	Yes	"	Caucasian	4 months	3
23	22	/ 2	/ 64	M	7-0	No	Yes	"	"	4 days	2
24	26	/ 2	/ 64	M	6-12	No	Yes	N.A. Ind.	"	2 days	2
W 25	26	/ 2	/ 64	F	7-5	Yes	Yes	Caucasian	"	3 days	W 1
26	1	/ 11	/ 63	F	6-9	Yes	No	"	"	4 months	2
27	28	/ 11	/ 63	M	7-12	Yes	Yes	"	"	4 months	2
28	2	/ 10	/ 63	F	8-2	No	Yes	"	"	5½ months	2
29	11	/ 3	/ 64	M	6-9	No	Yes	"	"	1 day	2
W 30	11	/ 3	/ 64	M	6-8	No	Yes	"	"	4 days	W 1
31	27	/ 7	/ 62	M	8-7	No	Yes	"	"	3 months	4
32	3	/ 12	/ 62	M	7-5	Yes	No	"	"	3 months	4
33	12	/ 7	/ 62	F	8-0	No	Yes	"	"	3 months	4
34	30	/ 12	/ 56	M	8-2	Yes	No	"	"	8 months	5
35	17	/ 1	/ 55	M	7-4	Yes	No	"	"	5 months	6
36	1	/ 3	/ 59	F	8-2	Yes	No	"	"	6 months	5
37	1	/ 4	/ 64	F	6-8	Yes	No	"	"	9 days	3
38	12	/ 4	/ 64	F	8-2	No	Yes	"	"	13 days	2

Θ Number of pairs used in this study.

* Child removed from the study by the parents.

W Moved.



Fig. 9. Wax Bite

(b) Impressions.--A trial mix of one measure of fast set alginate (Jeltrate) with warm tap water was made, spatulating for 20 seconds. The temperature of the tap water was approximately 95°F. Setting time after spatulation was noted. With a water temperature of 95°F, it was found that the setting time after twenty seconds of spatulation was thirty-five seconds.

The child was placed face down on a pillow with its head slightly overlapping one end (Fig. 10). A new mix of Jeltrate was made using the same water temperature as in the trial mix, again spatulating for twenty seconds.

The material was then placed in a tray lined with soft wax. Five seconds before the calculated setting time, the tray was placed in the child's mouth. The child was held firmly and the tray was seated into place. It was removed in approximately ten seconds. For lining the trays, (Moyco) red counter wax was found to be most suitable. Both impressions were taken with the operator crouching and facing the child. The impressions, until poured in "Alabastone" were stored in a humidicator, or wrapped in a moist paper towel. The acrylic perforated trays (Fig. 11) made on models obtained from stock tray impressions, were used for the impressions of children up to two years of age. For older children small metal stock trays were used.

(c) Casts.--One hundred and forty grams of "Alabastone" were mixed briefly in a rubber bowl with 38 cc. of tap water. The mix was transferred to a mechanical spatulating bowl and given about thirty turns. The mixed material was vibrated within the bowl, then into the impression, a little at a time, until it was overflowing. The remaining "Alabastone" was poured evenly into a rubber form and the impression inverted in the centre. After the initial set the form was placed in the humidicator for final setting. All casts were trimmed to a set pattern, soaped and polished. (Fig. 12) The casts were trimmed in occlusion (Fig. 13) except when such grinding obliterated growth reference points.



Fig. 10. The Position of Baby During the Taking of Impressions



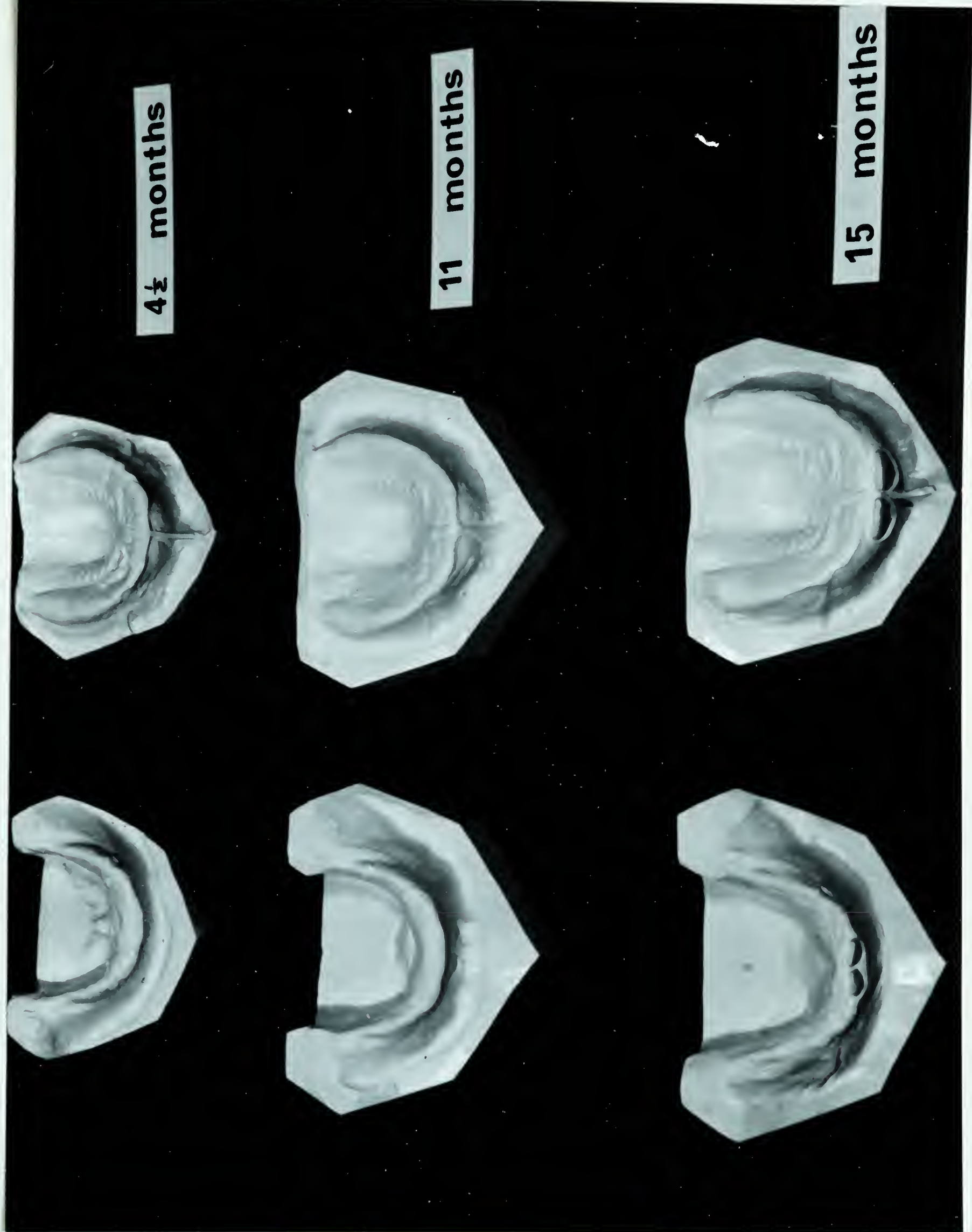


Fig. 12. Dental Casts from One Series

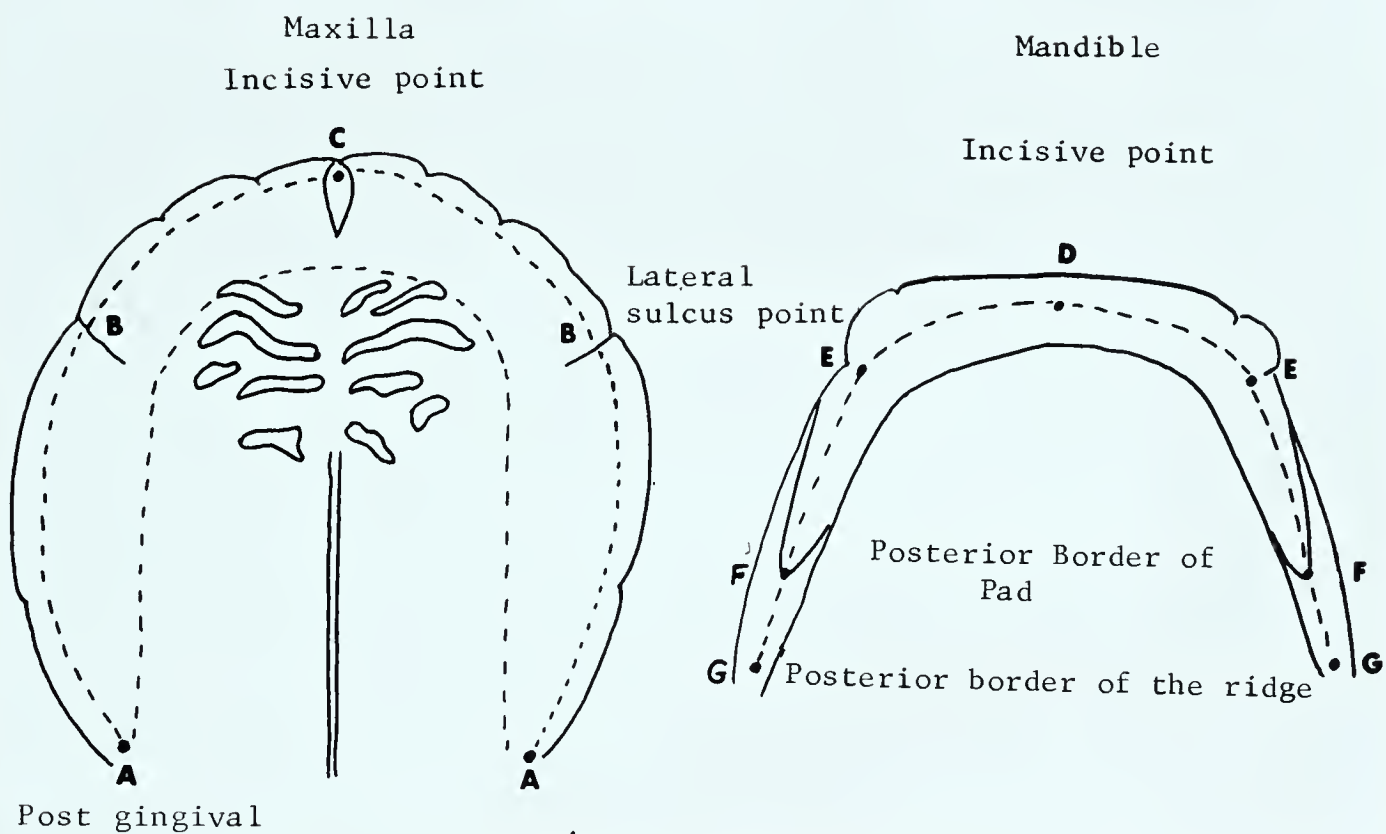


Fig. 14. Reference Points.

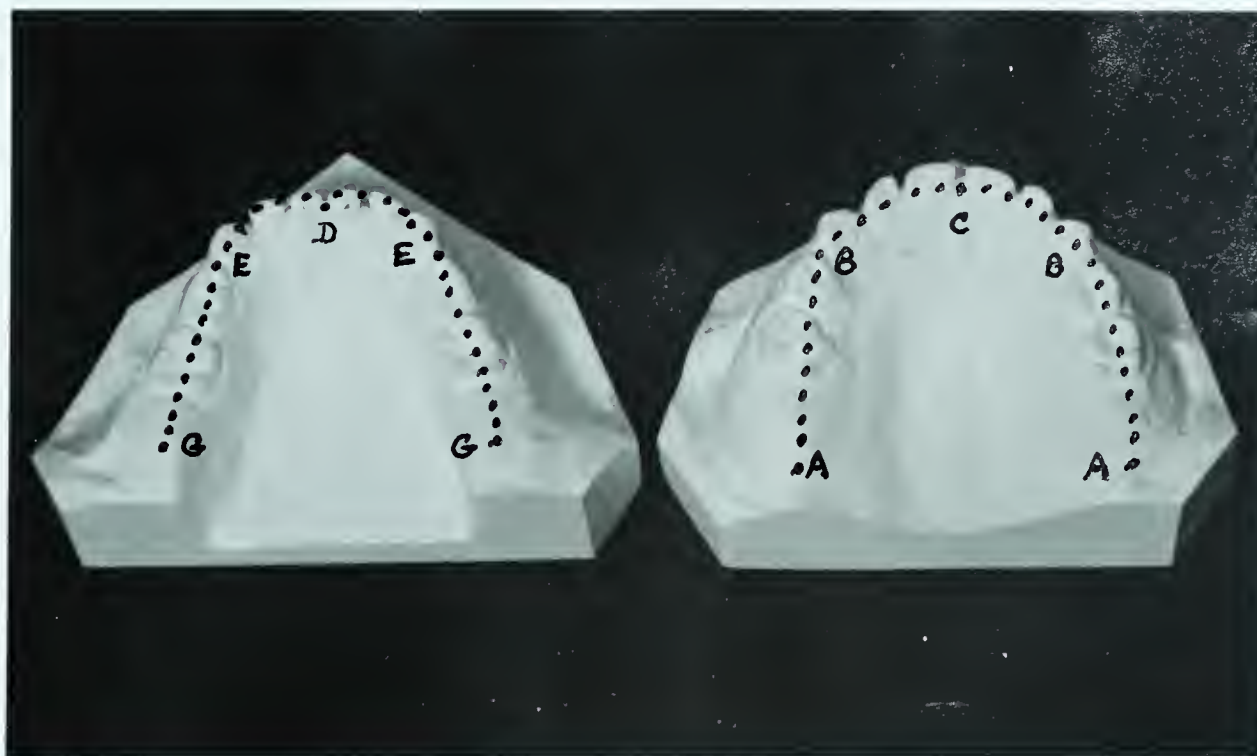


Fig. 15. Reference Points After Eruption of Deciduous Teeth

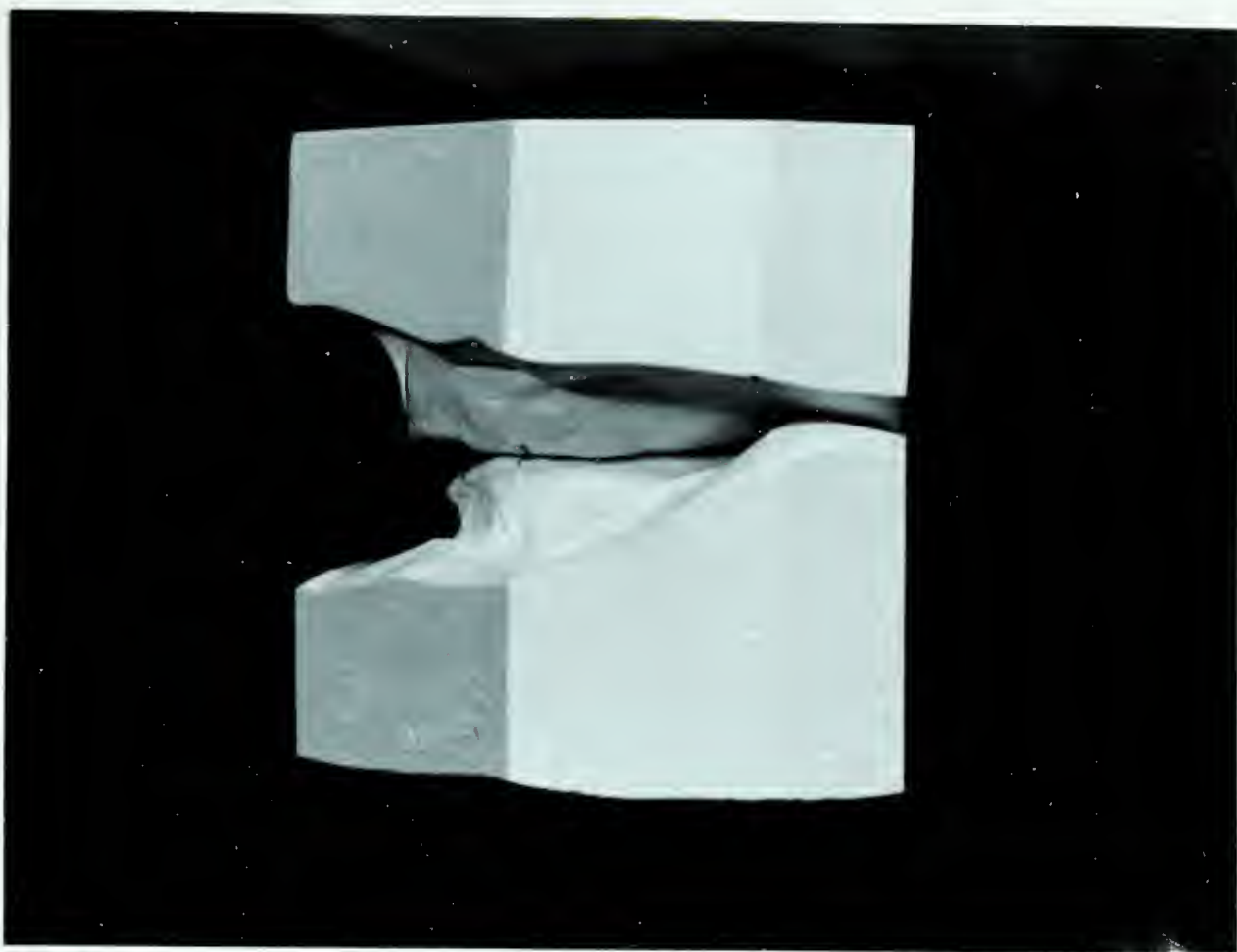


Fig. 13. Predentition Casts in Occlusion

B. Measurements

1. Points of Reference

- (a) Growth.--In order to measure any change in size due to growth it was necessary to locate reference points that could be established on each cast in each series. The points had to be identifiable on the casts before, during, and after the eruption of the deciduous teeth. After a careful study of the literature, personal examination of many casts and consultation with the Department of Anatomy, the necessary points were established. A list and description of such are presented in Table 15, and diagrammatically located in Figs. 14 and 15.

TABLE 15

REFERENCE POINTS

Landmark	Code	Description	
		Before Eruption	After Eruption
<u>Maxilla</u>			
Postgingival	A.	Posterior border of the gum pad at the crest of the ridge. Adjacent to the termination of the alveolar palatine groove.	Same as before eruption*
Lateral Sulcus Point	B.	The point at which the lateral sulcus crosses the crest of the ridge	The point on the crest of the ridge immediately distal to the deciduous canine. Remnants of the lateral sulcus are usually visible
Incisive point	C.	The most anterior point on the incisive papilla in line with the crest of the ridge	Same as before eruption. The incisors erupted labial to the crest of the ridge, thus not disturbing the incisive point
<u>Mandible</u>			
Incisive Point	D.	The point where the mid-line crosses the crest of the ridge in the anterior segment	Mid point between the central incisors or contact points. The incisors erupted through the crest of the ridge
Lateral Sulcus Point	E.	The point at which the lateral sulcus crosses the crest of the ridge	A point on the crest of the ridge immediately distal to the deciduous canine
Posterior Border of the Pad	F.	Posterior margin of the pad where it drops to posterior ridge	With the eruption of the second deciduous molars, this point is destroyed
Posterior Border of the Ridge	G.	The point at which the mandibular ridge terminates	Same as before eruption

* (Re: Table 15) With the eruption of the second deciduous molar, this point was noted to be immediately distal to the second molar. However, with further growth, this point continued to move distally.

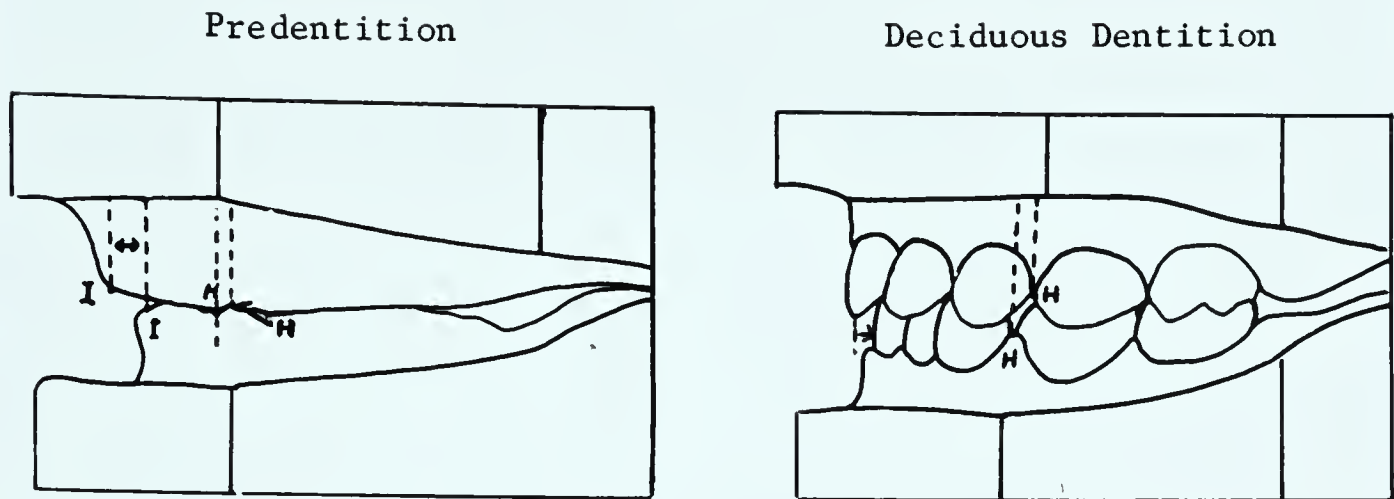


Fig. 16 . Occlusal Reference Points.

(b) Occlusion.--To observe and record changes in the occlusal relationship of the ridges, the following reference points were chosen. (See Table 16 and Fig. 16)

TABLE 16

OCCLUSAL REFERENCE POINTS

Landmark	Code	Description	
		Before Eruption	After Eruption
Canine Area	H.	Where the lateral sulcus crosses the crest of the ridge	Immediately distal to the deciduous canines
Incisor Area	I.	The point where the crest of the ridge crosses the mid line on both gum pads	<u>Maxilla</u> : The incisal edge of the most normal central incisor <u>Mandible</u> : The labial surface of the most normal central incisor



Fig. 17. Pantograph

2. Methods of Measuring

- (a) Arch Growth.-- The reference points were marked in pencil on the casts. If there was any doubt as to the exact location, assistance was obtained from the Department of Anatomy. Using a pantograph (Fig. 17) a line following the crest of the ridges and passing through the points of reference was drawn to a magnification of two times. As the ridge contours were being traced, the reference points were noted and transferred to the tracing, (Fig. 18). The crest of the ridge could still be followed when teeth were present. However, some observations and adjustments were necessary (Fig. 15). These are as follows:

1. Maxilla:

It was noted that the incisors and canines erupted labially to the crest of the ridge. Thus, when the teeth are erupted the crest of the ridge passes over the lingual surface of the incisors and canines at or near the junction of the middle-gingival thirds. In most cases, the teeth were spaced thus aiding the location of the line.

In the molar area it was noted that the crest of the ridge corresponded to the central fossae of the deciduous molars. Thus, the line passed from the posterior landmark, (Point A.) through the central fossae to the lateral point (B). In most first molars, this line passed through or near the medial buccal line angle.

2. Mandible:

From observing several casts, it was noted that the incisors erupted through the crest of the ridge, placing the contour line through the incisal edges. Adjustments were made for tooth rotation. The molar area was traced in a fashion similar to the maxillary molar area.

After the contour and points of reference had been transferred to the paper with the pantograph, the incisal edges of the anterior teeth were transferred.

The various maxillary tracings in each series were recorded on the same sheet of paper, which was numbered and dated. The mandibular casts were handled in the same manner.

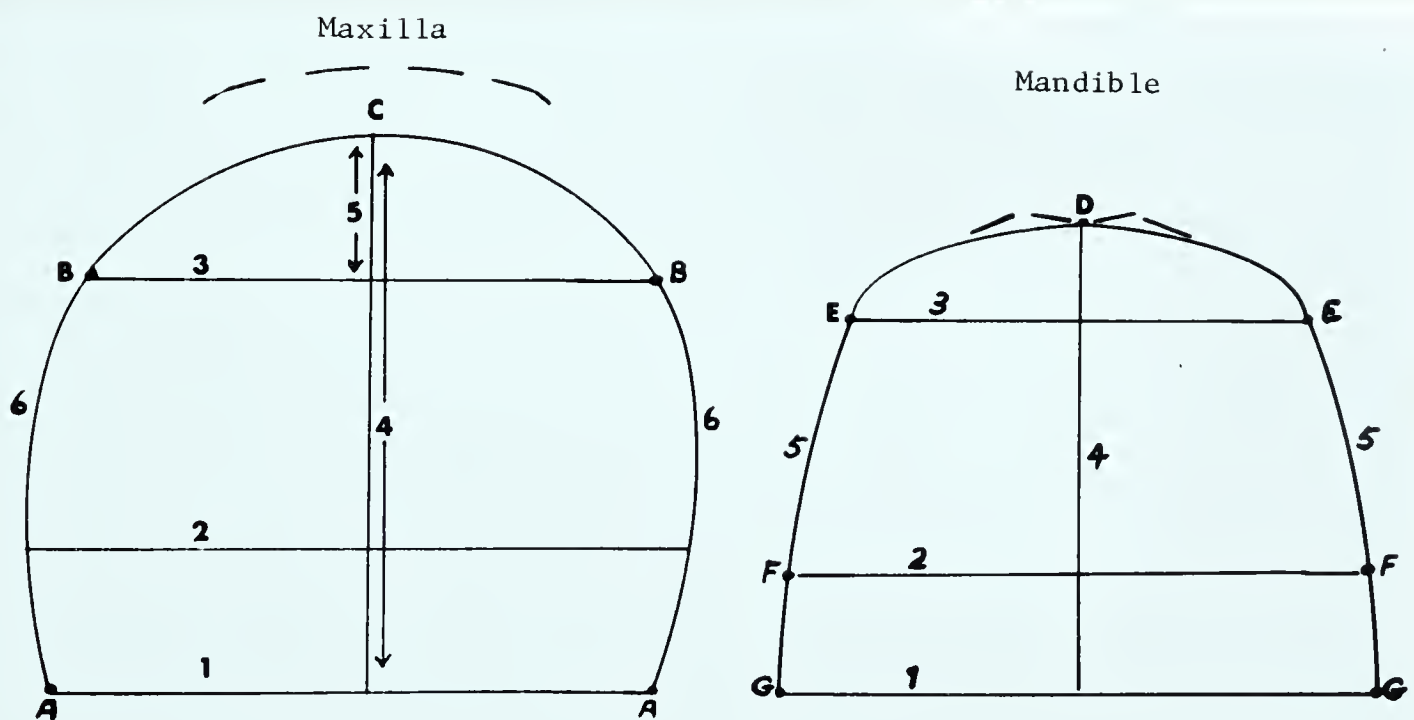


Fig. 18. Pantograph Tracing showing Reference Points, Measurement cords, and Incisor Teeth.

Upon the pantograph tracings, the following cords were drawn:
(Fig. 18).

<u>Maxilla</u>	<u>Mandible</u>
1. A - A	1. G - G
2. Maximum width	2. F - F
3. B - B	3. E - E
4. C - mid point	4. D - mid point of F - F
5. C - mid point of B - B	

On these completed pantograph tracings a number of measurements were taken. These are listed and described in Table 17. All measurements were divided by two. To reduce error, direct measurements were made on the casts using the reference points already marked. The casts and pantograph measurements were then compared and the mean recorded as the final measurement of that particular cord. All measuring was done with a caliper graduated to .05 mm. (Mitutoyo of Japan).

TABLE 17

GROWTH MEASUREMENTS

Measurement	Description
<u>Maxilla</u>	
1. Posterior Palatal Width	The distance between the postgingivum A - A
2. Maximum Palatal Width*	The greatest width of the maxillary arch
3. Anterior Palatal Width*	The distance between the lateral sulcus points B - B
4. Maximum Palatal Length	From the incisive point to the middle of the posterior width cord
5. Anterior Palatal Length	From the incisive point to the anterior width cord, following the mid-palatal line
6. Palatal Arch Length	Following the arch contour, the distance from A to A passing through B, C, and B
<u>Mandible</u>	
1. Posterior Ridge Width*	The distance between the right and left posterior borders of the ridge G - G
2. Posterior Pad Width*	The distance between the right and left posterior borders of the pad F - F
3. Anterior Width*	The distance between the lateral sulcus points E - E
4. Mid Line Length	The distance from the incisive point (D) to the middle of the posterior ridge width cord, F - F
5. Arch Length	The total arch length from G to F, following the crest of the ridge

* Measured on dental casts and pantograph tracings.

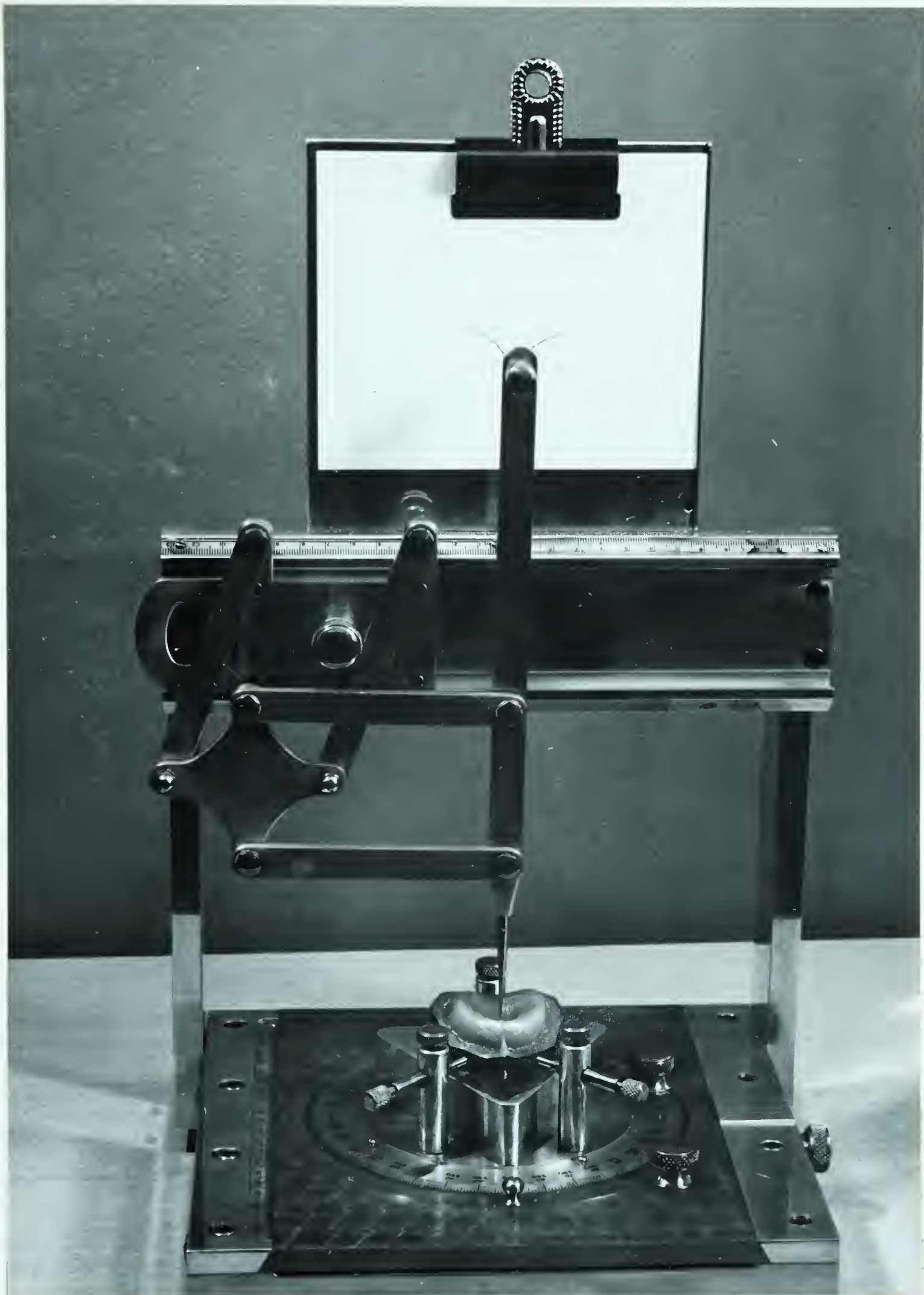


Fig. 19. Symmetrograph

(b) Palatal Vault Growth.--A prominent identifiable point on the rugae was marked on each maxillary cast in a series (Point R.). This point was similar to each cast within the series. However, there was no need to have similarity between series.

The first cast of a series was then orientated on the modified Korkhaus symmetrograph (Fig. 19). The cast was fixed so that the pointer followed the mid line when the pointer moved laterally. The cast was then rotated 90° and a perpendicular dropped to the mid line from the postgingival point that was most easily identified. The point where the pointer crossed the mid line was marked and recorded as J. The table was then moved ten millimeters so that the pointer rested on the mid line ten millimeters anterior to J. This new point was marked on the cast and recorded as K.

The table was then moved so the pointer could be placed on point R. A perpendicular was then traced to the mid line and point R' marked on the mid line. By moving the table, the distance from R' to K was measured and recorded. These points are depicted in Fig. 20.

In each succeeding cast of the series, points J and K were obtained from points R and R'. This procedure was followed in an attempt to have points J and K as stable as possible, unaltered by eruption of teeth and posterior ridge growth.

The transverse contour of the palate at point J and K were traced out and recorded. Each tracing extended from the alveolar palatine groove, through the depth of the vault, to the opposite alveolar palatine groove.

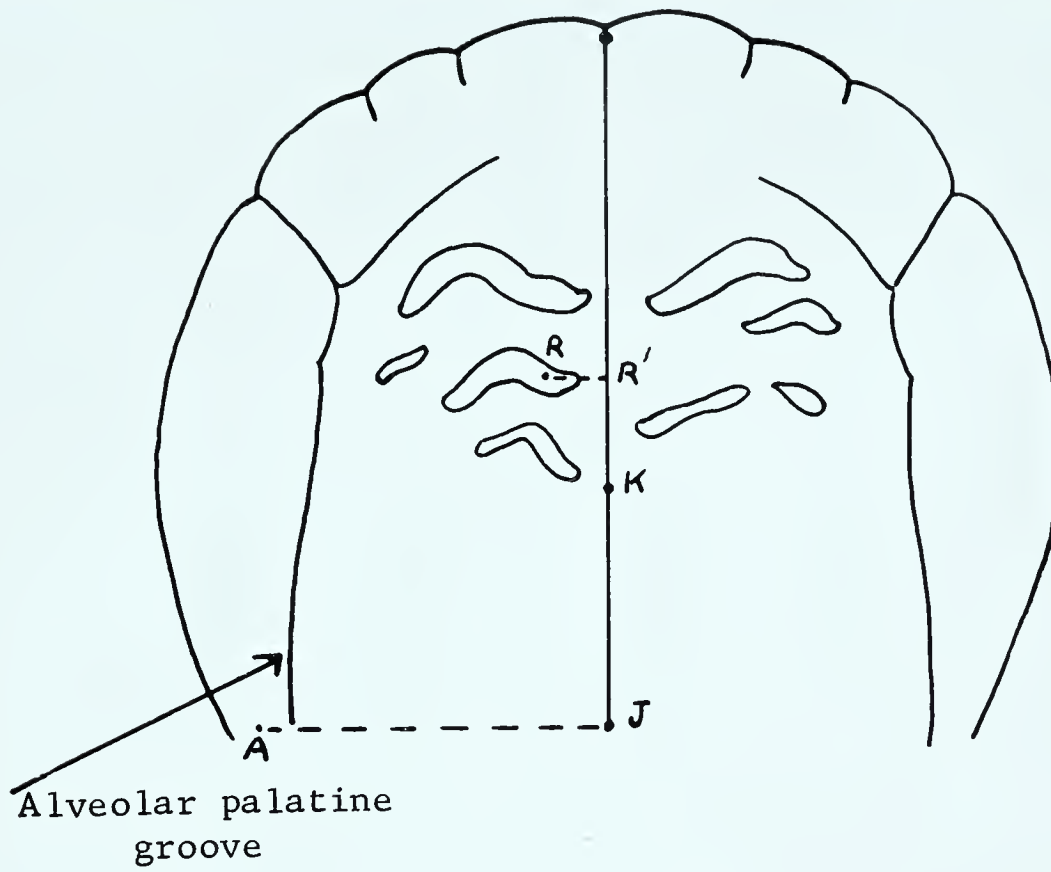


Fig. 20. Palatal Reference Points

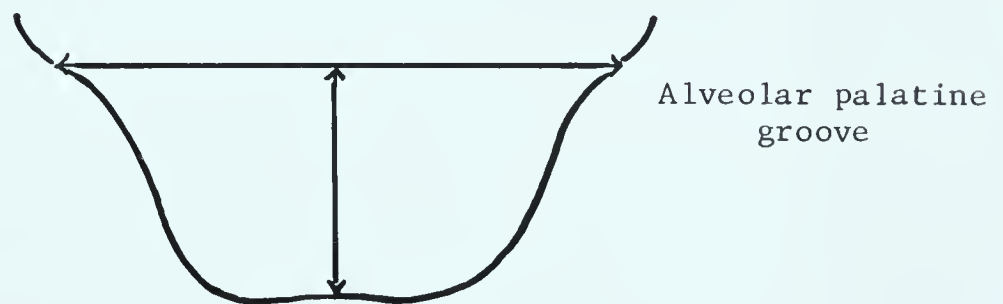


Fig. 21. Palatal Tracing Showing Measurement Cord.

The following measurements were made on these tracings: (Fig 21).

1. Palatal Width at J.
2. Palatal Width at K.
3. Palatal Height at J.
4. Palatal Height at K.

Again the measurements were made with the caliper previously described.

- (c) Occlusal Relationship.--With the aid of points of reference previously described, a series of measurements were made with the cast occluded. These are listed and described in Table 18.

TABLE 18

OCCLUSAL RELATION MEASUREMENT

Measurement	Description
Overjet-Anterior Area	The distance between point I on the maxilla and point I on the mandible in the horizontal place.
Anterior Posterior Relation in Canine Area	The distance between two parallel lines perpendicular to the base of the mandibular cast and passing through the maxillary and mandibular H points.
Overbite Per Cent	The per cent of overlap of the maxillary central incisors to the mandibular central incisors. (A range of 0 - 10%: minus only if bite is open).
Pre-eruption Anterior Opening	Vertical distance between the maxillary and mandibular ridges in the incisor area

(d) Eruption of Teeth and Movement After Eruption.--

Eruption: At the first visit, an eruption chart was given to the parent who was asked to record the date at which the teeth were first seen projecting through the soft tissues. At each succeeding visit, they were reminded to continue using the chart.

Movement of the Teeth: Measurements of tooth position (Fig. 22) were made from the pantograph drawing and from the casts.

1. Pantograph Drawing:

With the incisal edges of the incisors transferred, the angles between these straight (incisal) lines and the mid line were measured to the nearest degree.

2. Casts:

(a) The greatest mesial distal diameter of the incisor teeth was measured. Each measurement was divided in half. A point was then marked on the respective teeth half way between the mesial and distal margins at the greatest width. The shortest distance between the mid points on the incisor teeth and the mid line of the casts were measured with the caliper.

(b) The smallest distances between all erupted adjacent teeth were measured. A minus reading was obtained when the teeth were overlapped due to crowding.

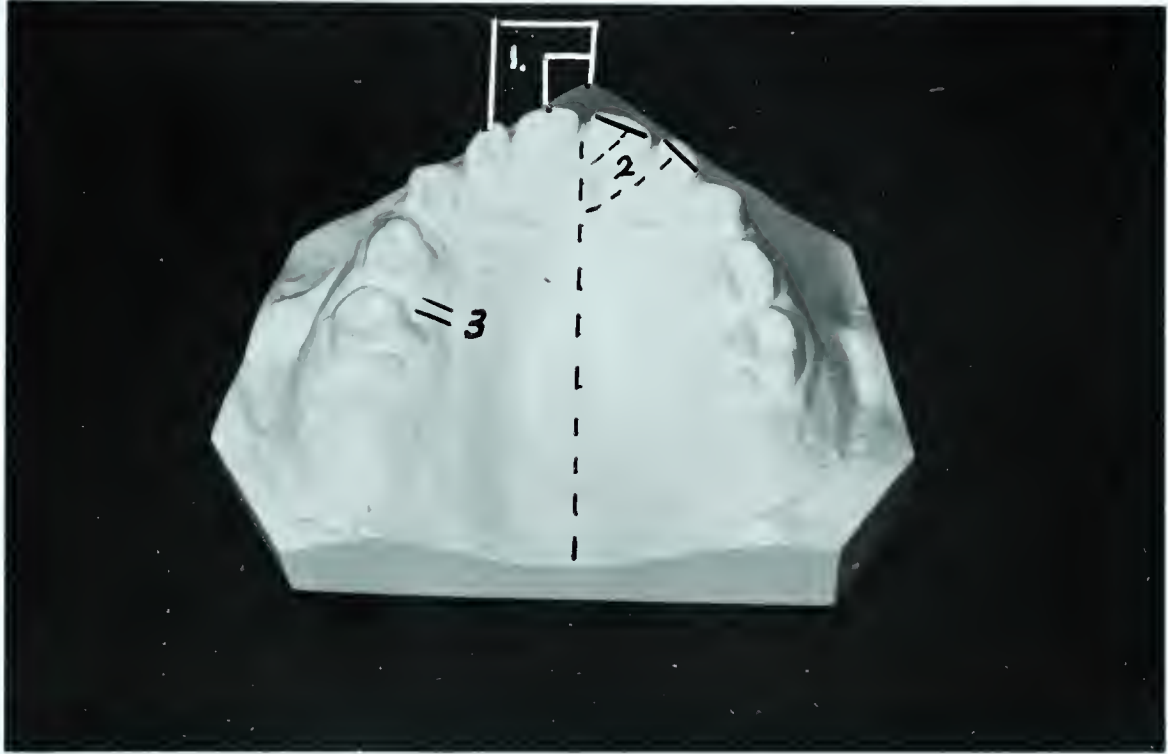


Fig. 22. Position of Deciduous Teeth

1. Distance from incisors to the mid line
2. Angle of incisors to the mid line
3. Space between adjacent teeth

3. Recording of Data

Sample recording forms for each case are seen in Figures 23, 24, 25

NO.	NAME	RACE	SEX	BOTTLE	BREAST
Measurement	Method	Age in Months			
Anterior	M				
Palatal Breadth	P				
	X				
Maximum	M				
Palatal Breadth	P				
	X				
Posterior	M				
Palatal Breadth	P				
	X				
Maximum	P				
Palatal Length					
Anterior	P				
Palatal Length					
Palatal	P				
Arch Length					
Posterior	M				
Mandibular Width	P				
	X				
Anterior	M				
Mandibular Width	P				
	X				
Mandibular	M				
Posterior Pad	P				
Width	$\bar{X}$				
Mandibular	P				
Arch Length					
Mandibular	P				
Mid line Length					
Palatal	S				
Height at A					
Palatal	S				
Height at B					
Palatal	S				
Width at A					
Palatal	S				
Width at B					

M = Model
P = Pantograph

$\bar{X}$ = Mean of P and M
S = Symmetrograph

Fig. 23. Form for Recording Growth Measurements

NO.

NAME

OCCLUSION

Measurement	Age in Months					
Overjet anterior.						
Overjet cuspid.						
Overbite percent.						
Anterior opening.						

ERUPTION

Particulars.	Deciduous Teeth																			
	E	D	C	B	A	A	B	C	D	E	E	D	C	B	A	A	B	C	D	E
Eruption time.																				
Order of Eruption.																				
Total Eruption Time.																				

Fig. 24. Form for Recording Occlusal Relation and Eruption Times

Age in Months													
Measurement.	Maxilla	Mandible	Maxilla	Mandible	Maxilla	Mandible	Maxilla	Mandible	Maxilla	Mandible	Maxilla	Mandible	Maxilla
1. Mid Line to incisors.													
(a) centrals	Right												
	Left												
(b) laterals	Right												
	Left												
2. Angle of incisors to midline.													
(a) centrals	Right												
	Left												
(b) laterals	Right												
	Left												
3. Spaces between the teeth.													
(a) central incisors													
(b) central and lateral	Right												
	Left												
(c) lateral and canine	Right												
	Left												
(d) canine 1st. molar	Right												
	Left												
(e) 1st. & 2nd. molars	Right												
	Left												

Fig. 25. Form for Recording Tooth Position

RESULTS

A. Growth

All recorded growth measurements were tabulated according to age groups, with each group spanning 3 months (Tables 19, 20). Age groups were used because the impressions were not always taken at the same age for every child. The chief reason being because it was not possible to have the parents bring the children in for impressions at exactly the date requested due to such reasons as sickness, moving, holidays, etc. Because of the total time available for the study few measurements beyond 24 months of age were obtained. Scatter diagrams (Fig. 26, 1 to 11) were drawn for all arch growth cords.

From Tables 19 and 20, means and standard deviations were calculated for all growth measurements at seven age groups (0-3 months), (3-6 months), (6-9 months), (9-12 months), (12-15 months), (15-18 months), (18-21 months) (Tables 21,22). Due to the small numbers beyond 21 months of age, calculations beyond this age were not done. Using the calculated means, line graphs were drawn for the growth measurements (Figs. 27, 28, 29).

TABLE 19 - 1

ANTERIOR PALATAL LENGTH

Age in Months										
0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24	24-27	27-30	30-33
6.0	7.6	8.4	7.7	10.2	8.2	8.3	10.0		10.4	10.8
7.0	9.6	8.1	8.4	9.7	10.7	8.6	10.0		11.1	
7.3	9.3	8.5	10.2	9.0	10.3	9.8	7.8		8.9	
8.0	7.3	8.5	8.8	9.8	8.5	8.2	10.6		9.6	
6.1	8.0	9.5	10.2	8.6	9.5	9.5	9.5			
7.0	7.0	8.8	8.0	7.8	10.9	9.0	11.7			
7.0	8.3	8.3	8.8	8.9	10.8	10.6				
	7.6	9.3	9.2	8.6	8.8	10.9				
	8.2	9.0	8.1	8.4	8.9					
	8.7	9.4	8.0	7.4	8.7					
	8.3	10.4	7.8	8.6	9.3					
	8.0	9.4	11.0	8.5	11.3					
	8.0	6.8	9.7	11.7	9.6					
	9.0			10.7	8.5					
	8.4									
	10.3									
	8.5									
	7.5									
	7.8									
	8.1									
	8.3									
	9.1									
	7.2									
	8.7									
	8.6									

Measured in millimeters

TABLE 19 - 2

MAXIMUM PALATAL LENGTH

0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24	24-27	27-30	30-33
19.4	25.8	27.5	28.0	27.6	27.8	32.5	33.6		35.9	
22.7	27.3	26.8	29.4	28.2	31.4	30.2	32.1			
25.1	28.0	28.4	29.0	29.8	31.7	31.8	33.5			
23.4	26.6	29.4	29.2	30.7	28.9	33.6				
23.1	26.7	28.3	27.9	28.9	30.0	31.2				
22.1	25.6	27.9	27.7	28.8	27.2	31.2				
22.7	24.5	23.7	29.1	29.3	32.3	32.0				
	27.0	27.0	28.4	29.6	32.2					
	25.0	27.8	27.9	29.4	29.8					
	27.3	26.8	29.2	27.7	28.4					
	27.5	33.6	28.3	28.7	30.7					
	29.6	33.6	28.3	28.7	30.7					
	29.6	31.5	31.2	32.0	33.3					
	29.6		30.8	31.9	29.8					
	27.5				31.5					
	25.8									
	29.9									
	25.4									
	29.0									
	26.8									
	27.4									
	28.3									
	27.7									
	27.0									
	28.1									
	27.4									
	27.4									

Measured in millimeters

TABLE 19 - 3

POSTERIOR PALATAL WIDTH

Age in Months										
0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24	24-27	27-30	30-33
28.00	27.65	29.70	33.05	31.05	30.25	32.45	28.55		35.46	35.34
26.55	28.50	30.04	35.80	33.80	34.45	33.15	34.08		33.10	
29.70	30.15	31.50	27.40	30.70	31.20	35.00	30.15			
27.10	31.50	29.15	32.15	30.65	32.55	34.60	33.70			
25.90	30.90	31.45	32.15	32.65	33.05	32.00	32.55			
27.00	30.45	29.75	29.50	30.85	29.45	28.00				
27.80	31.10	33.45	31.50	31.55	31.60	33.30				
	32.55	29.50	28.50	32.10	35.80	31.60				
	30.00	27.75	27.70	35.05	35.25					
	29.80	26.55	31.85	34.95	34.05					
	31.10	31.80	31.50	34.85	38.70					
	29.20	26.15	29.80	28.75	28.20					
	31.65	29.82	31.40	28.35	39.85					
	27.10			31.75	28.50					
	28.80									
	26.60									
	28.85									
	32.85									
	27.40									
	30.40									
	29.10									
	31.65									
	29.20									
	26.25									
	30.10									

Measured in millimeters

TABLE 19 - 4

ANTERIOR PALATAL WIDTH

Age in Months										
0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24	24-27	27-30	30-33
25.20	26.40	27.50	27.35	27.40	28.00	30.55	27.75		29.18	29.49
26.30	26.40	27.60	31.30	27.85	27.80	25.30	28.26		28.90	
26.60	28.55	29.90	26.95	29.80	28.60	31.25	28.50		28.60	
24.75	27.75	30.10	28.40	28.10	27.95	32.70	28.00			
26.25	27.90	27.80	26.85	28.40	27.25	27.20	28.77			
24.30	24.20	27.80	27.65	24.10	27.70	26.00	35.88			
24.40	27.15	29.15	27.60	29.29	30.15	28.75				
	29.80	27.60	26.90	27.23	34.10	28.31				
	26.75	28.00	26.15	29.50	27.90					
	28.75	25.40	30.20	30.40	30.40					
	25.70	30.90	27.55	26.10	32.75					
	26.60	24.80	27.60	26.00	28.90					
	27.45	22.65	31.70	27.65	26.45					
	26.50				27.60					
	26.20				26.70					
	25.10				27.15					
	26.85									
	29.80									
	25.40									
	29.00									
	27.15									
	28.40									
	27.15									
	24.80									
	25.50									
	29.25									

Measured in millimeters

TABLE 19 - 5

PALATAL ARCH LENGTH

0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24	24-27	27-30	30-33
59	68	74	76	76	75	85	82		89	
64	70	71	81	74	79	77	83			
66	73	77	72	80	80	85	83			
63	71	78	77	77	76	90				
61	72	74	72	76	77	79				
61	70	74	74	74	70	78				
61	67	67	74	77	82	81				
	76	74	74	80	90					
	69	72	74	80	79					
	75	69	79	76	80					
	72	84	76	74	79					
	76	78	79	78	81					
	78		83	80	77					
	68				81					
	75									
	69									
	80									
	71									
	76									
	76									
	75									
	74									
	70									
	73									
	76									

Measured in millimeters

TABLE 19 - 6

MANDIBULAR MID-LINE LENGTH

Age in Months										
0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24	24-27	27-30	30-33
17.1	18.6	23.5	20.8	22.2	22.4	27.1	26.2		30.6	
17.2	17.6	18.9	21.4	21.7	22.9	25.4	26.7			
17.6	21.7	21.0	19.6	22.9	22.7	23.2	26.7			
17.1	18.7	19.3	19.7	23.3	25.0	27.5				
15.0	17.6	20.0	20.1	21.2	21.0	23.3				
15.7	21.1	18.7	20.0	23.3	23.2	26.6				
16.7	20.5	21.0	22.9	21.9	24.4	28.3				
	19.2	22.7	21.0	21.10	24.0					
	20.1	22.5	22.3	22.4	23.8					
	20.7	19.7	26.5	26.4	22.9					
	18.8	23.1	21.5	22.7	24.1					
	22.3	22.4	24.4	21.7	25.7					
	23.0		25.0	24.0	25.2					
	21.5			26.2	26.7					
	20.5									
	20.9									
	18.4									
	22.2									
	19.6									
	18.8									
	17.7									
	19.1									
	18.6									
	20.7									
	21.0									
	19.2									

Measured in millimeters

TABLE 19 - 7

MAXIMUM PALATAL WIDTH

Age in Months										
0 - 3	3 - 6	6 - 9	9 -12	12-15	15-18	18-21	21-24	24-27	27-30	30-33
29.30	29.50	32.25	36.00	33.85	32.20	36.45	33.00		35.45	35.81
30.30	31.45	32.63	39.65	35.89	37.15	35.20	34.50		37.00	
31.90	32.90	35.85	30.25	35.10	33.35	38.80	35.10		34.60	
30.40	34.30	34.45	36.10	31.55	34.95	38.60	33.20			
30.80	34.10	34.75	33.45	35.33	34.20	34.65	35.28			
29.15	32.75	33.60	32.20	33.60	32.05	30.35	35.85			
29.70	33.00	36.85	33.00	35.75	35.40	34.70				
	36.90	31.95	32.60	32.00	40.85	32.95				
	31.80	31.30	31.30	37.60	38.30					
	33.60	27.80	34.50	36.40	38.40					
	34.80	37.05	33.90	36.75	32.80					
	33.10	30.80	33.30	30.70	32.40					
	34.30	31.66	37.10	31.40	32.90					
	31.40			33.30	33.60					
	30.10				32.40					
	30.30									
	32.30									
	37.60									
	29.30									
	33.30									
	32.90									
	35.20									
	32.50									
	28.90									
	29.60									
	35.70									

Measured in millimeters

TABLE 19 - 8

POSTERIOR MANDIBULAR WIDTH

Age in Months										
0 - 3	3 - 6	6 - 9	9 -12	12-15	15-18	18-21	21-24	24-27	27-30	30-33
30.40	30.40	32.40	34.25	34.84	32.55	34.00	32.55		32.87	
30.30	30.24	30.17	37.00	34.20	36.15	35.25	31.12		36.80	
32.10	33.05	33.80	30.50	34.10	33.10	37.50	35.85			
30.60	33.40	31.55	33.55	33.00	34.75	38.75	32.55			
30.90	33.55	33.90	34.10	34.50	33.80	34.75				
28.41	33.10	32.20	31.35	32.90	32.65	35.00				
29.20	29.70	36.35	32.15	31.75	33.55	35.00				
	35.30	31.50	32.65	31.77	38.70					
	31.90	31.50	33.30	35.20	38.25					
	32.90	30.50	33.30	38.15	37.40					
	32.85	34.65	32.30	36.80	33.50					
	34.00	32.70	32.90	34.25	32.45					
	35.15		31.40	31.20	32.70					
	31.40			33.90	35.60					
	30.90									
	30.10									
	33.00									
	35.90									
	30.90									
	32.35									
	30.90									
	35.80									
	32.00									
	31.05									
	30.10									

Measured in millimeters

TABLE 19 - 9

ANTERIOR MANDIBULAR WIDTH

Age in Months										
0 - 3	3 - 6	6 - 9	9 -12	12-15	15-18	18-21	21-24	24-27	27-30	30-33
20.90	22.35	23.20	23.90	22.90	23.10	25.55	23.30		23.69	23.97
21.40	22.90	25.90	26.10	24.20	25.25	21.25	23.45		24.75	
24.40	25.15	25.35	24.35	24.70	24.05	25.55	25.80		23.65	
21.60	23.50	22.60	25.25	24.00	23.60	26.45	23.95			
22.05	24.85	24.15	22.90	23.80	23.90	23.10	23.80			
21.15	19.78	23.40	22.70	21.35	24.20	23.35	25.85			
21.90	19.55	27.20	23.50	22.45	23.00	24.35				
	26.05	22.80	22.75	24.84	27.75	23.45				
	21.25	21.65	23.20	25.45	23.90					
	24.00	23.20	24.30	25.70	25.70					
	22.90	25.60	23.15	25.40	23.00					
	25.00	24.60	25.30	23.60	21.60					
	23.75	22.34	27.80	21.45	22.20					
	21.60			25.20	25.00					
	22.15				24.15					
	22.30									
	21.75									
	26.30									
	22.70									
	21.10									
	25.40									
	22.30									
	23.10									
	23.25									
	23.60									
	23.20									

Measured in millimeters

TABLE 19 - 10

MANDIBULAR POSTERIOR PAD WIDTH

Age in Months										
0 - 3	3 - 6	6 - 9	9 -12	12-15	15-18	18-21	21-24	24-27	27-30	30-33
28.60	28.40	29.70	31.85	32.20	31.00	33.85	31.45		30.44	
28.40	29.40	30.17	34.75	33.20	33.40	32.10	30.39			
30.30	30.45	32.00	28.70	33.15	30.90	35.55	33.75			
28.80	31.45	30.90	31.45	30.05	32.45	35.20	33.80			
28.90	29.50	31.35	31.35	32.05	32.55	32.65				
27.40	26.75	30.35	29.55	30.70	30.40	31.90				
28.15	33.95	33.45	31.75	30.10	31.60	31.40				
	29.10	29.45	30.20	30.00	37.00					
	31.10	29.40	31.90	34.05	34.15					
	30.50	28.10	30.55	35.40	34.45					
	30.65	32.10	31.10	34.65	31.25					
	31.20	30.50	33.30	31.70	29.65					
	28.50			29.20	31.65					
	28.70			31.85						
	28.60									
	34.00									
	28.70									
	30.60									
	28.35									
	32.30									
	30.00									
	28.70									
	31.60									

Measured in Millimeters

TABLE 19 - 11

MANDIBULAR ARCH LENGTH

Age in Months										
0 - 3	3 - 6	6 - 9	9 - 12	12-15	15-18	18-21	21-24	24-27	27-30	30-33
53	57	65	60	61	61	72	66		78	
50	50	55	62	61	62	67	71			
55	62	61	55	62	65	67	72			
51	53	55	60	65	66	75				
47	57	58	57	60	60	65				
50	57	61	62	61	65	71				
	56	61	59	59	68					
	56	61	61	64	66					
	58	55	62	72	65					
	55	66	60	64	64					
	65	62	66	59	66					
	65		67	63	65					
	59			70	71					
	58									
	58									
	55									
	62									
	56									
	57									
	53									
	58									
	59									
	59									
	55									

Measured in millimeters

TABLE 20 -1
PALATAL VAULT WIDTH AT "J"

Age in Months								
0 - 3	3 - 6	3 - 6	6 - 9	9 - 12	12 - 15	15 - 18	18 - 21	21 - 24
21.7	22.3	22.7	22.5	22.9	24.4	24.8	24.8	23.8
20.7	21.8	22.5	23.0	23.1	23.0	23.9	24.5	23.6
24.5	23.9	21.0	25.5	23.0	25.0	26.1	27.2	24.9
19.4	24.8	23.1	23.3	24.7	24.0	24.8	26.0	21.0
20.6	24.5	25.6	24.3	23.2	23.8	24.8	21.8	21.2
	22.9	20.8	25.3	28.4	26.3	29.5	25.3	
	22.7	24.2	23.1	25.5	23.2	27.5	20.6	
	25.6	23.8	21.0	23.9	24.6	24.8		
	25.5	26.0	19.1	22.7	21.4	22.6		
	23.0	22.8	27.5	22.1	21.5	22.7		
	23.3	19.7	20.8	26.4	24.0	23.5		
	24.2	23.3	19.1	24.0		22.7		
		19.7	21.4	23.0				
				25.4				

Measured in millimeters

TABLE 20 - 2
PALATAL VAULT WIDTH AT "K"

Age in Months								
0 - 3	3 - 6	3 - 6	6 - 9	9 - 12	12 - 15	15 - 18	18 - 21	21 - 24
20.2	19.6	21.9	21.9	21.5	22.0	21.0	20.7	19.3
20.7	20.7	20.1	24.2	21.3	18.5	19.4	18.8	20.1
22.6	22.3	19.8	23.1	23.6	23.7	20.7	23.2	23.0
18.9	24.6	21.1	22.5	23.5	19.8	22.4	20.3	17.5
19.0	24.5	22.9	22.4	21.4	20.5	20.8	20.5	19.2
	18.7	19.9	21.8	26.6	22.8	19.5	17.5	19.5
	20.1	25.3	20.9	22.1	20.7	26.0	20.7	
	25.3	23.1	19.7	21.2	19.5	22.2	19.9	
	22.5	21.2	18.5	20.7	18.0	19.6		
	20.8	21.6	25.4	26.1	19.3	19.0		
	21.3	20.0	20.1	22.7	22.2	18.5		
	23.0	23.6	19.2	21.7	19.3	18.6		
		19.7	19.6	25.0		19.0		
				20.7		17.7		

Measured in millimeters

TABLE 20 - 3
PALATAL VAULT HEIGHT AT "J"

Age in Months								
0 - 3	3 - 6	3 - 6	6 - 9	9 - 12	12 - 15	15 - 18	18 - 21	21 - 24
3.5	3.3	4.8	4.0	3.3	4.5	4.6	6.2	6.1
3.7	3.7	3.6	4.8	4.3	6.5	6.7	6.5	5.6
4.4	5.2	4.0	4.2	5.3	4.8	6.0	4.7	7.3
4.0	5.6	5.5	4.3	4.3	5.7	5.4	5.4	7.0
4.6	3.9	4.2	4.7	4.6	5.7	5.9	4.1	5.5
	4.6	3.4	5.3	4.9	4.7	4.7	4.4	
	4.8	5.0	4.0	5.5	6.2	5.9	4.5	
	3.8	5.0	4.6	4.7	6.1	5.7		
	5.0	3.7	3.2	4.3	4.0	5.9		
	5.4	3.6	5.9	4.4	4.0	4.1		
	4.0	4.4	4.2	4.7		4.9		
	5.3	5.6	4.0	5.1		5.2		
	4.0		3.8	3.8				
				5.3				

Measured in millimeters

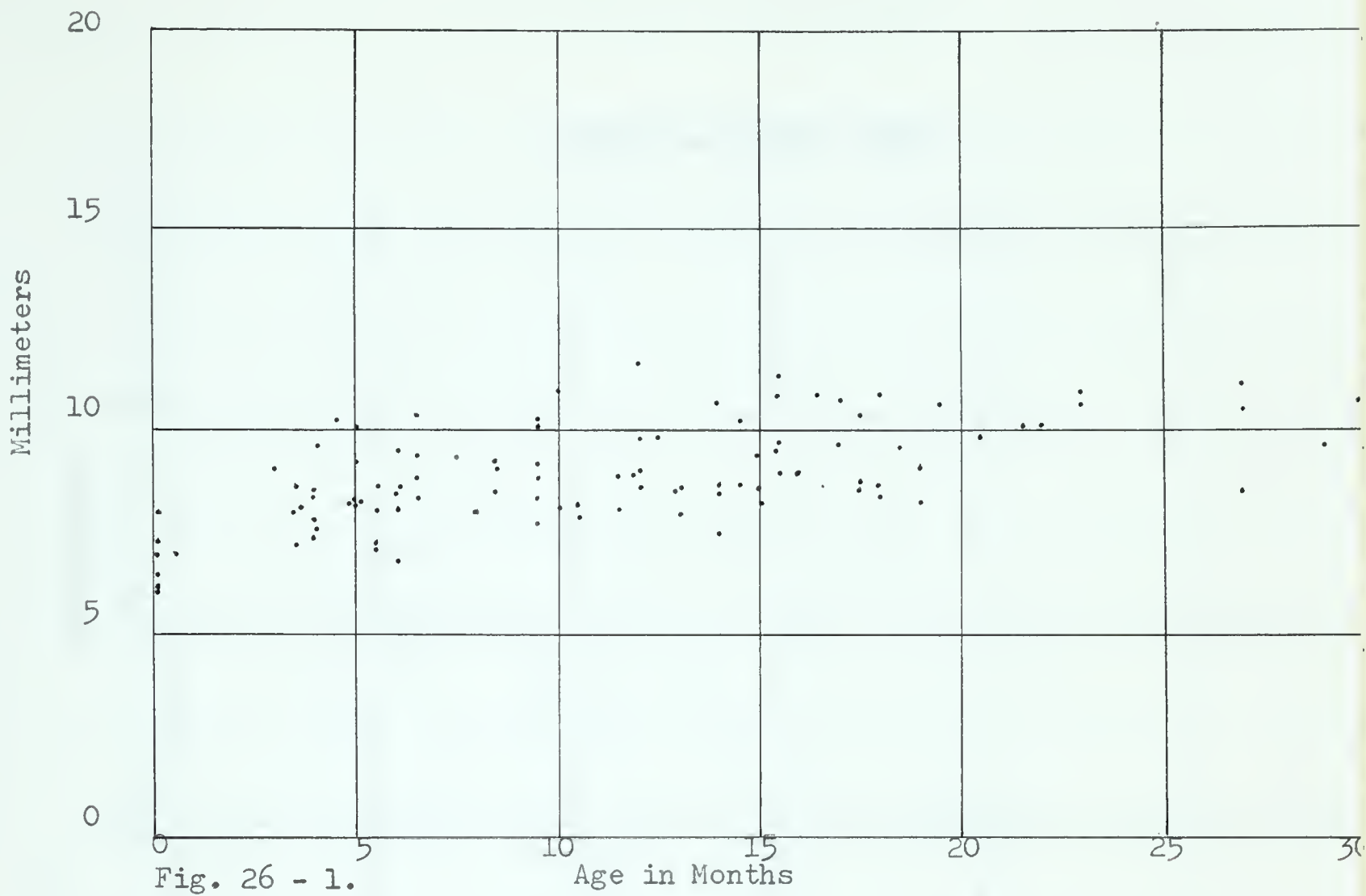
TABLE 20 - 4
PALATAL VAULT HEIGHT AT "K"

Age in Months								
0 - 3	3 - 6	3 - 6	6 - 9	9 - 12	12 - 15	15 - 18	18 - 21	21 - 24
4.7	4.5	6.5	5.9	5.5	5.9	6.1	7.0	6.6
5.2	5.8	5.7	6.5	7.3	6.6	6.6	7.0	8.4
6.6	7.3	6.2	5.3	7.2	8.6	8.0	5.5	7.5
4.9	8.0	5.7	6.3	6.0	7.4	7.1	6.6	7.2
5.6	6.1	6.1	6.8	6.1	6.2	6.9	7.5	6.4
	6.9	4.9	6.9	7.6	7.3	6.4	5.5	6.2
	5.6	5.7	5.5	7.0	5.5	7.2	7.4	
	6.7	6.3	6.0	7.3	6.0	6.5	6.3	
	6.6	5.8	5.5	6.4	7.5	7.0		
	6.5	7.3	7.8	5.0	6.1	6.7		
	5.5	6.6	6.7	7.1	5.8	6.2		
		6.3	5.9	7.2		5.7		
			5.8	7.3		7.8		
				7.3		6.7		

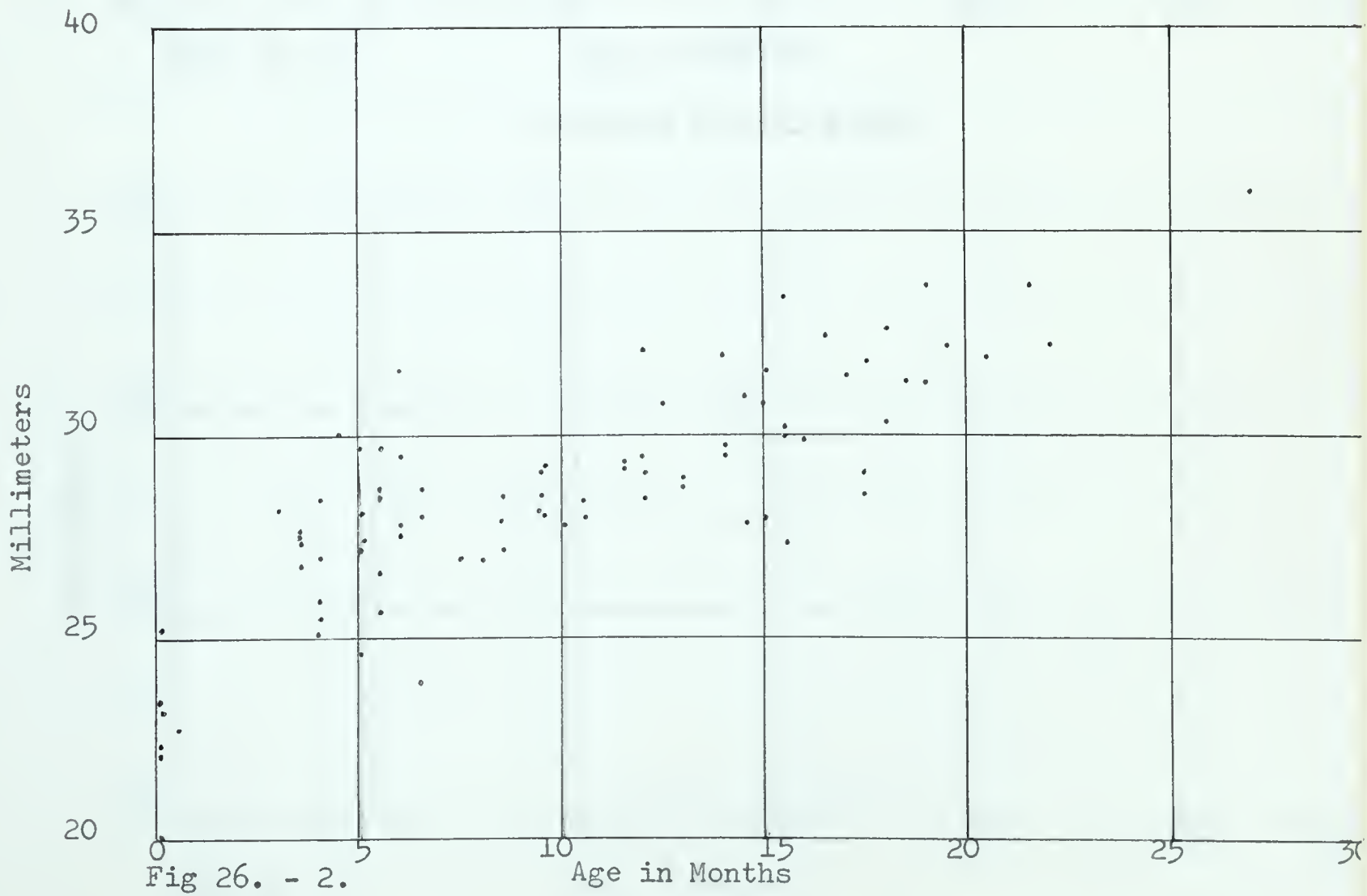
Measured in Millimeters



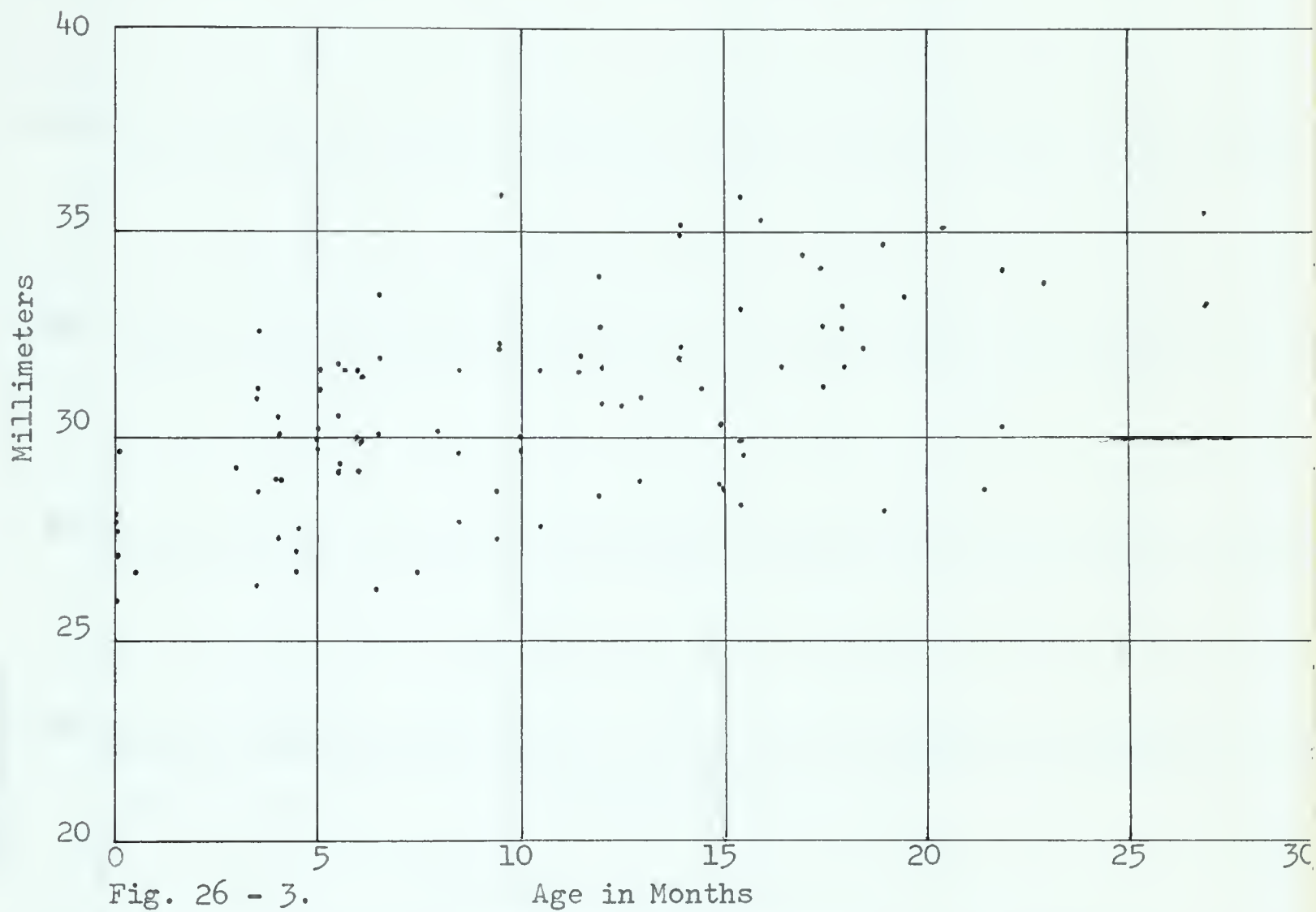
ANTERIOR PALATAL MID-LINE LENGTH



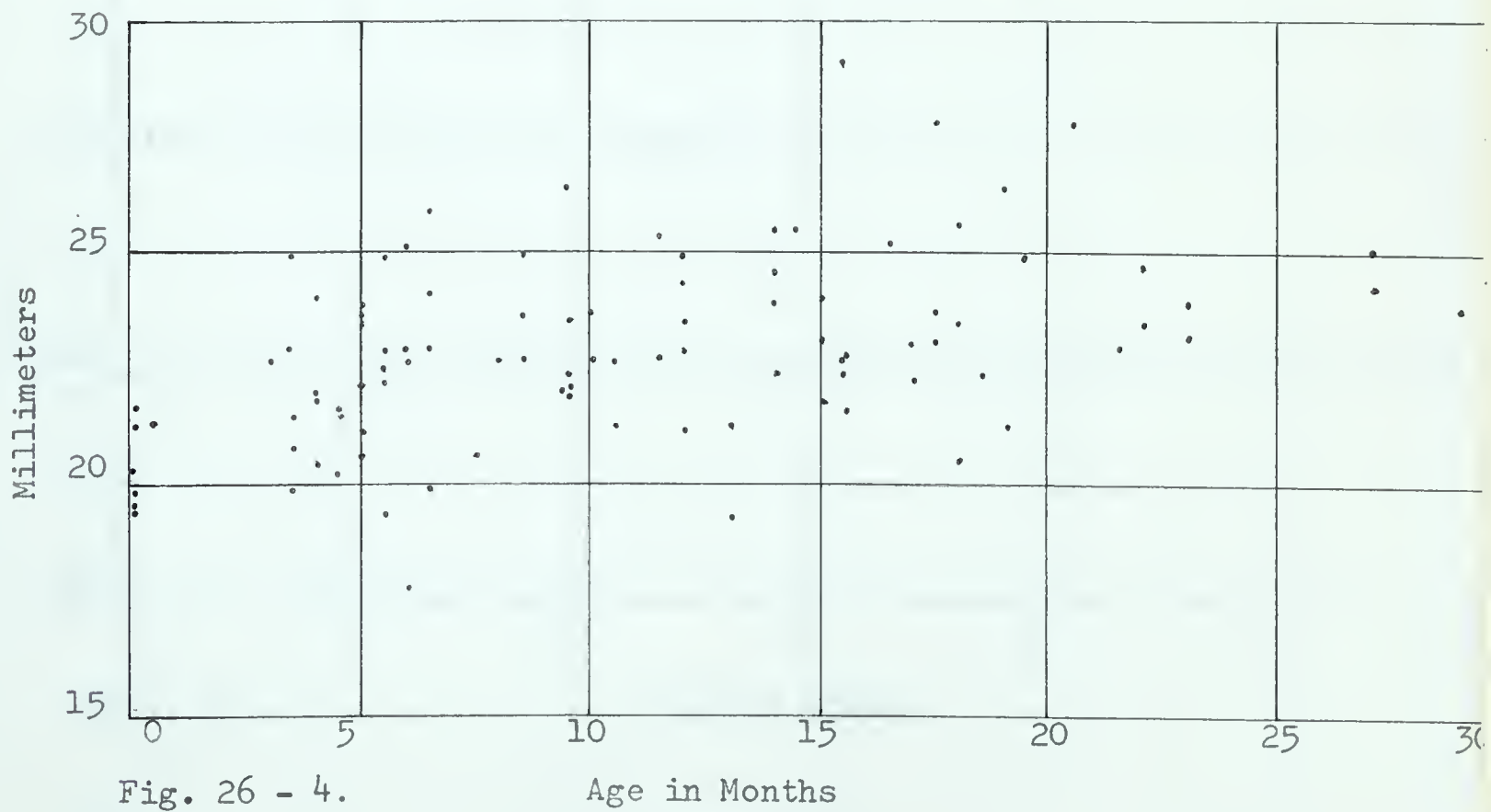
MAXIMUM PALATAL MID-LINE LENGTH



POSTERIOR PALATAL WIDTH



ANTERIOR PALATAL WIDTH



PALATAL ARCH LENGTH

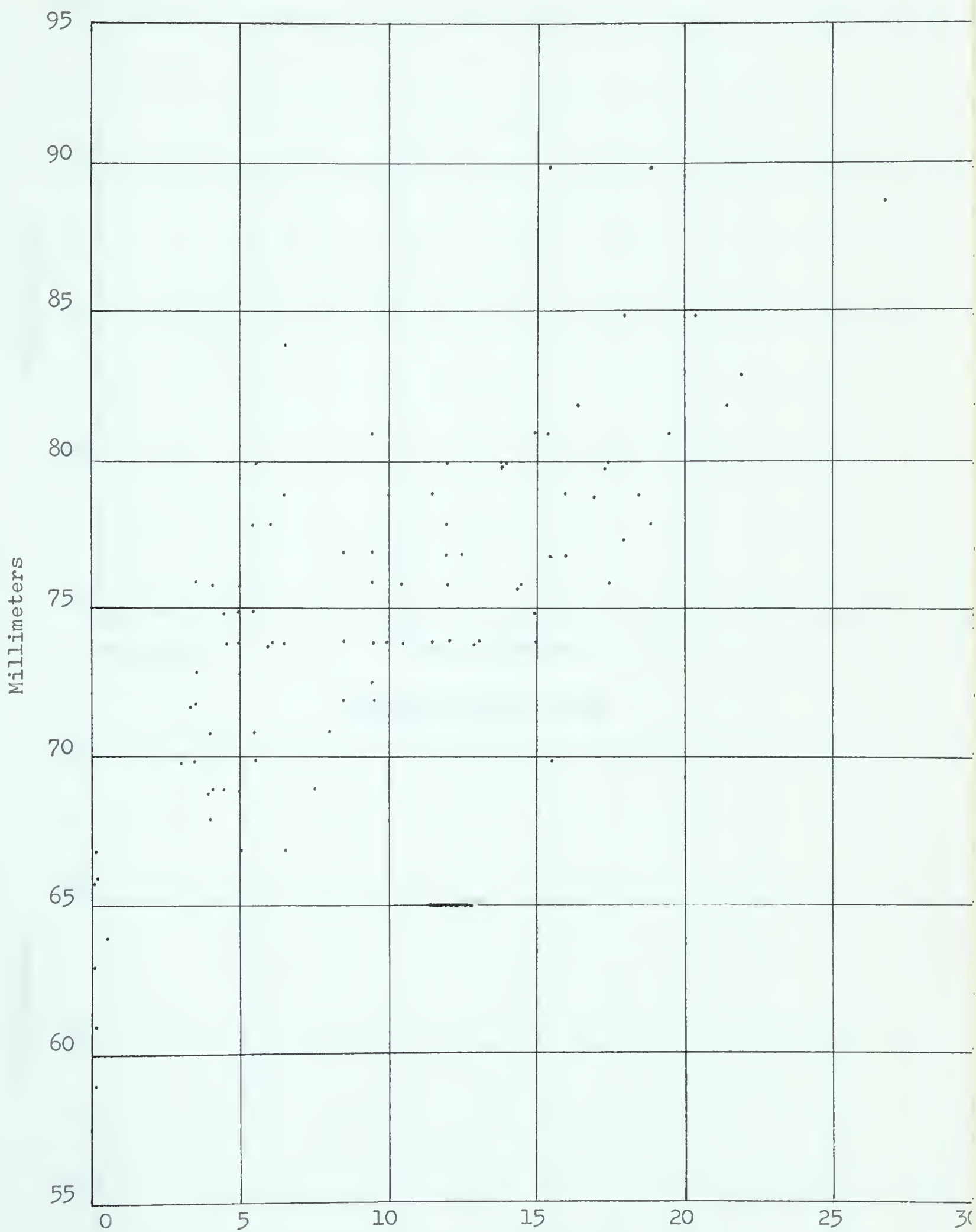
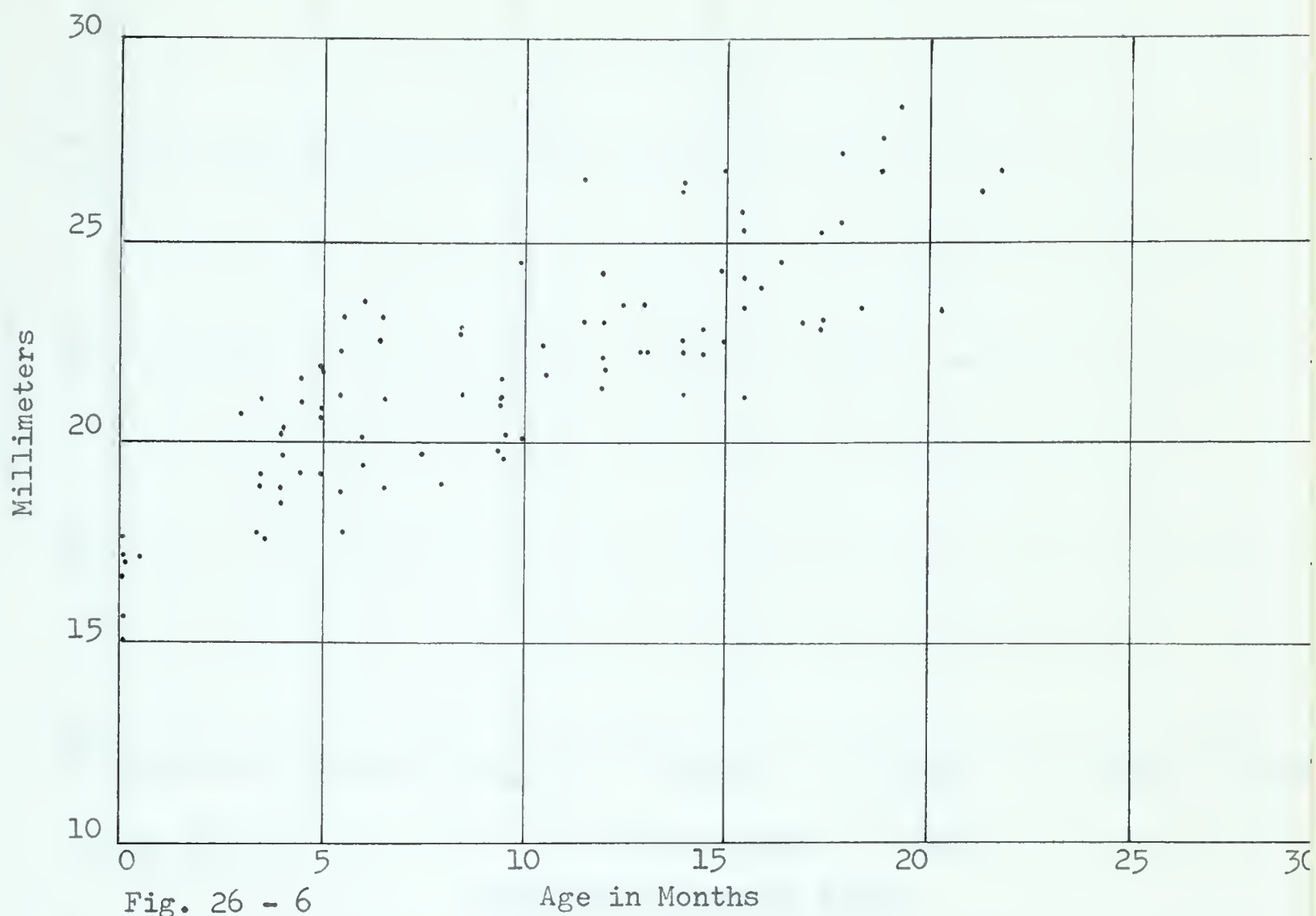


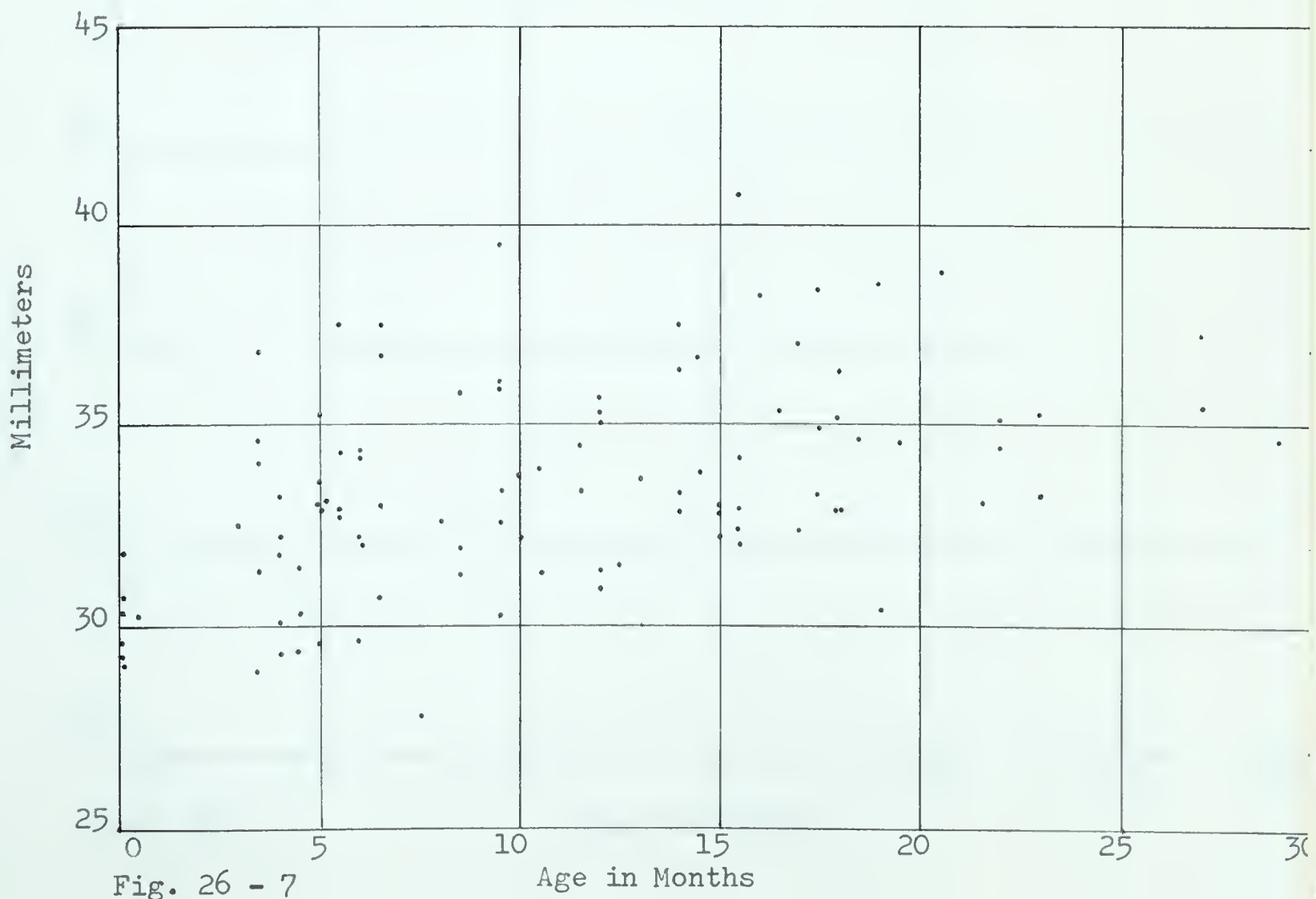
Fig. 26 - 5

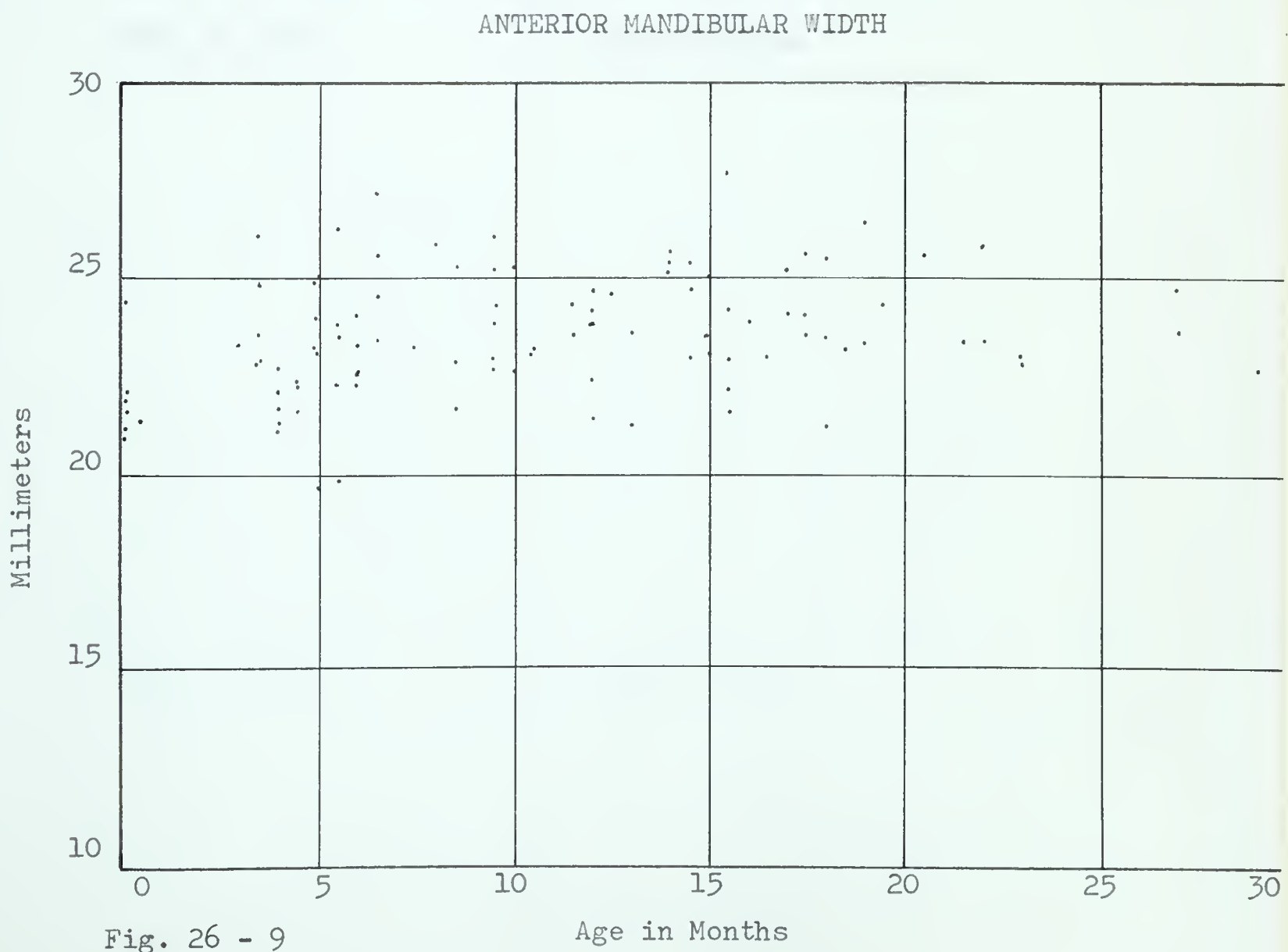
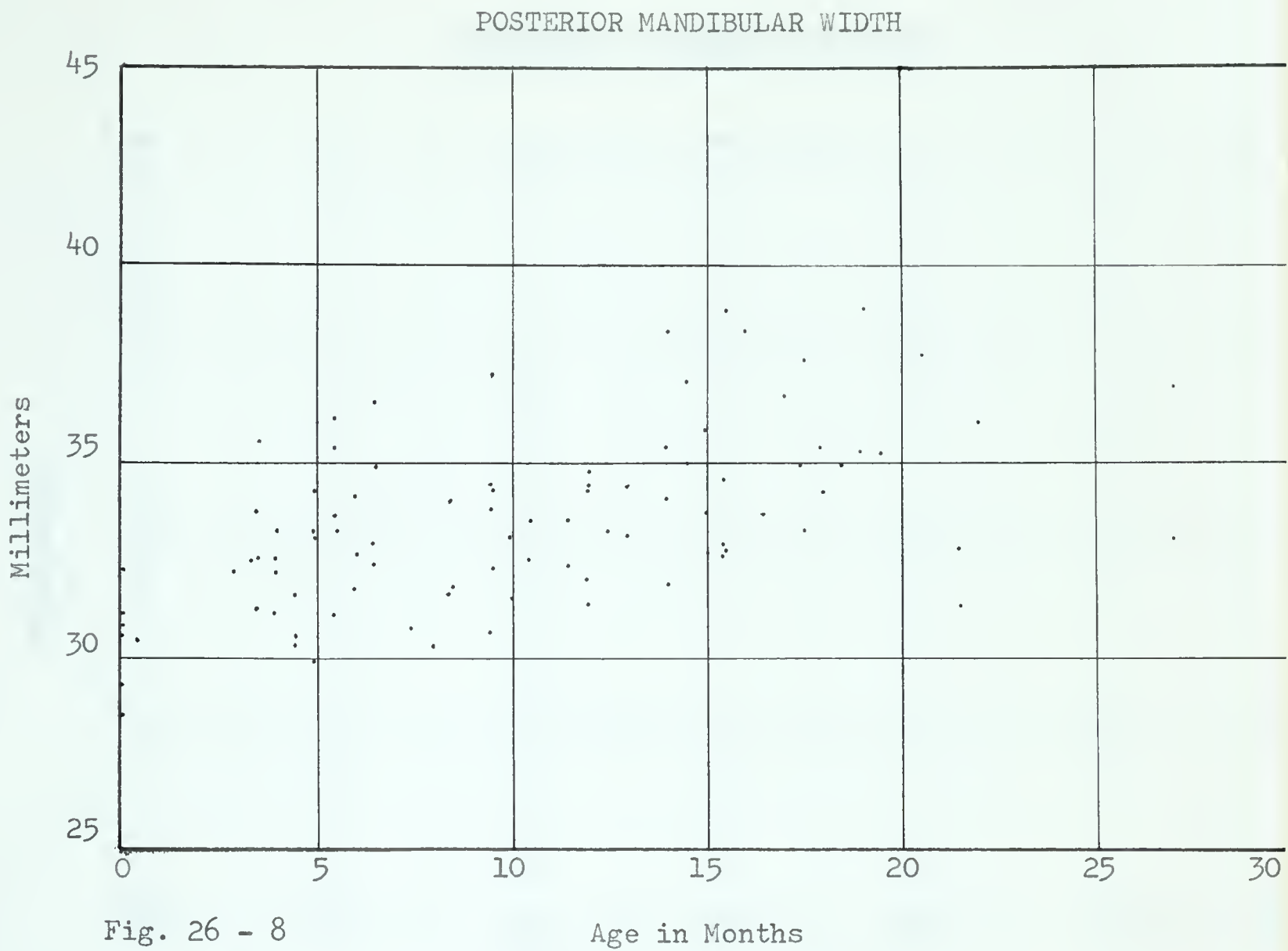
Age in Months

MANDIBULAR MID-LINE LENGTH

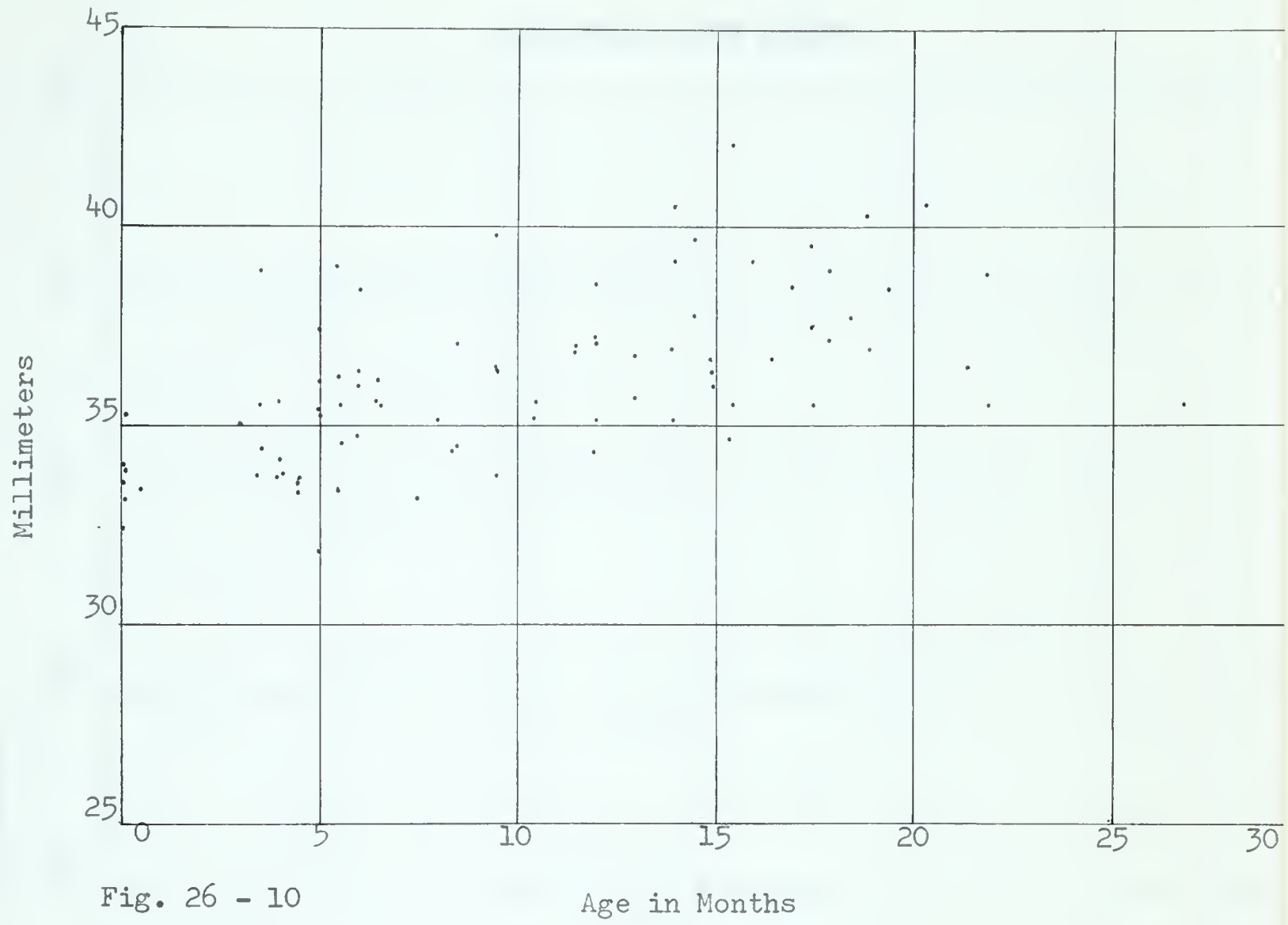


MAXIMUM PALATAL WIDTH





MANDIBULAR POSTERIOR PAD WIDTH



MANDIBULAR ARCH LENGTH

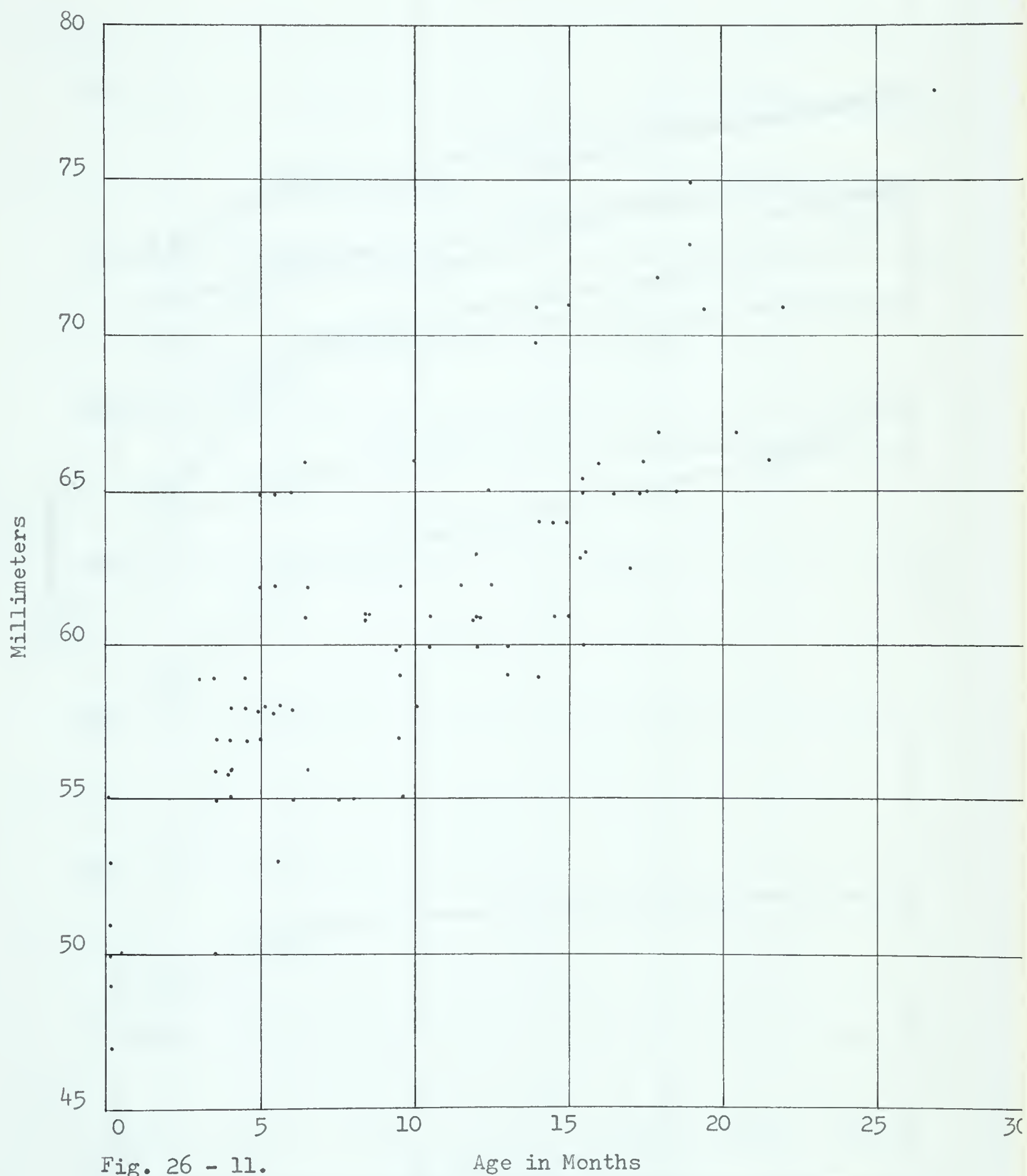


Fig. 26 - 11.

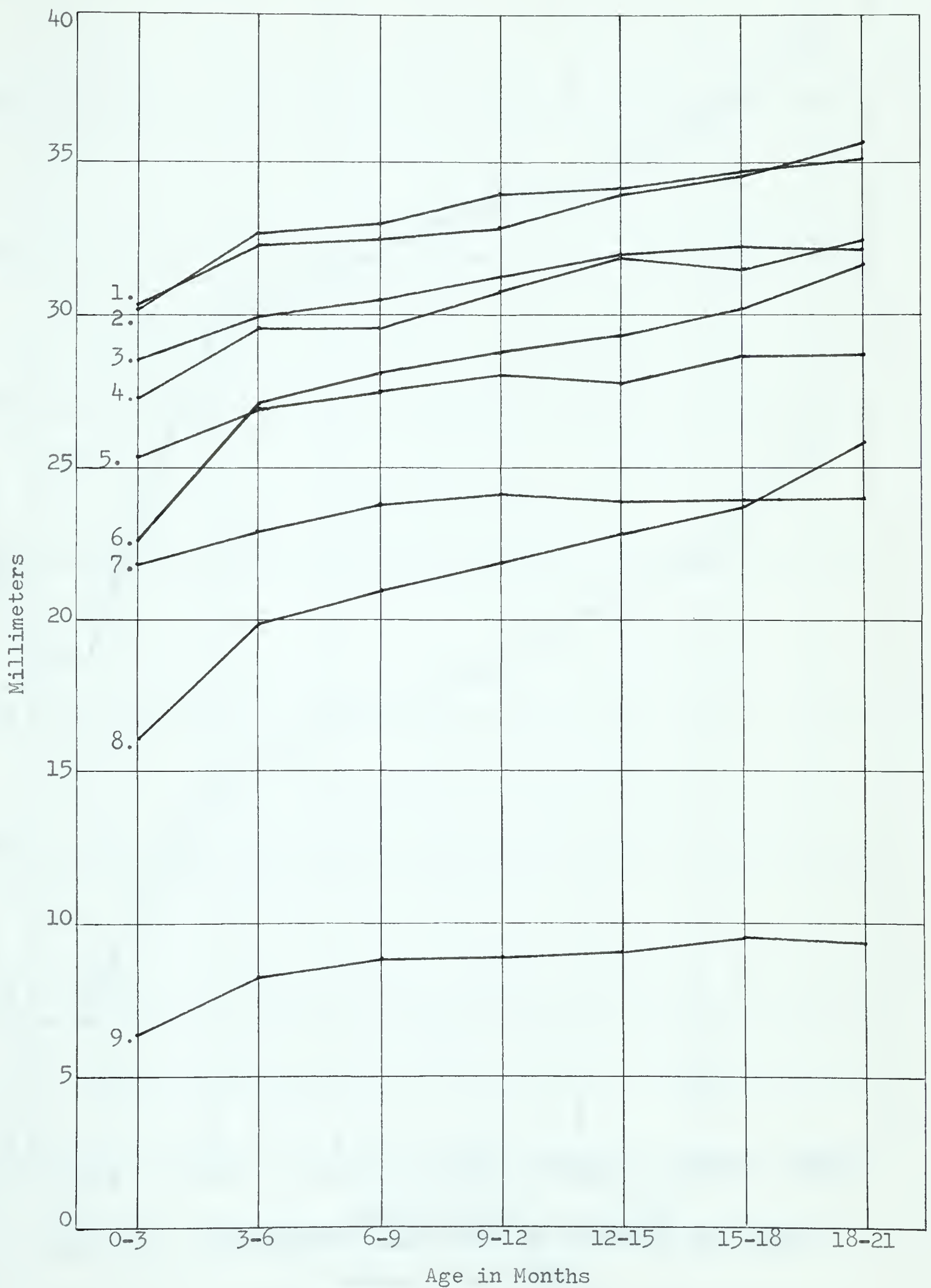


Fig.27 . MEAN GROWTH MEASUREMENTS AT DIFFERENT AGE GROUPS

- | | |
|-----------------------------------|-------------------------------|
| 1. Posterior Mandibular Width | 2. Maximum Palatal Width |
| 3. Posterior Mandibular Pad Width | 4. Posterior Palatal Width |
| 5. Anterior Palatal Width | 6. Maximum Palatal Length |
| 7. Anterior Mandibular Width | 8. Mandibular Mid-Line Length |
| 9. Anterior Palatal Length | |

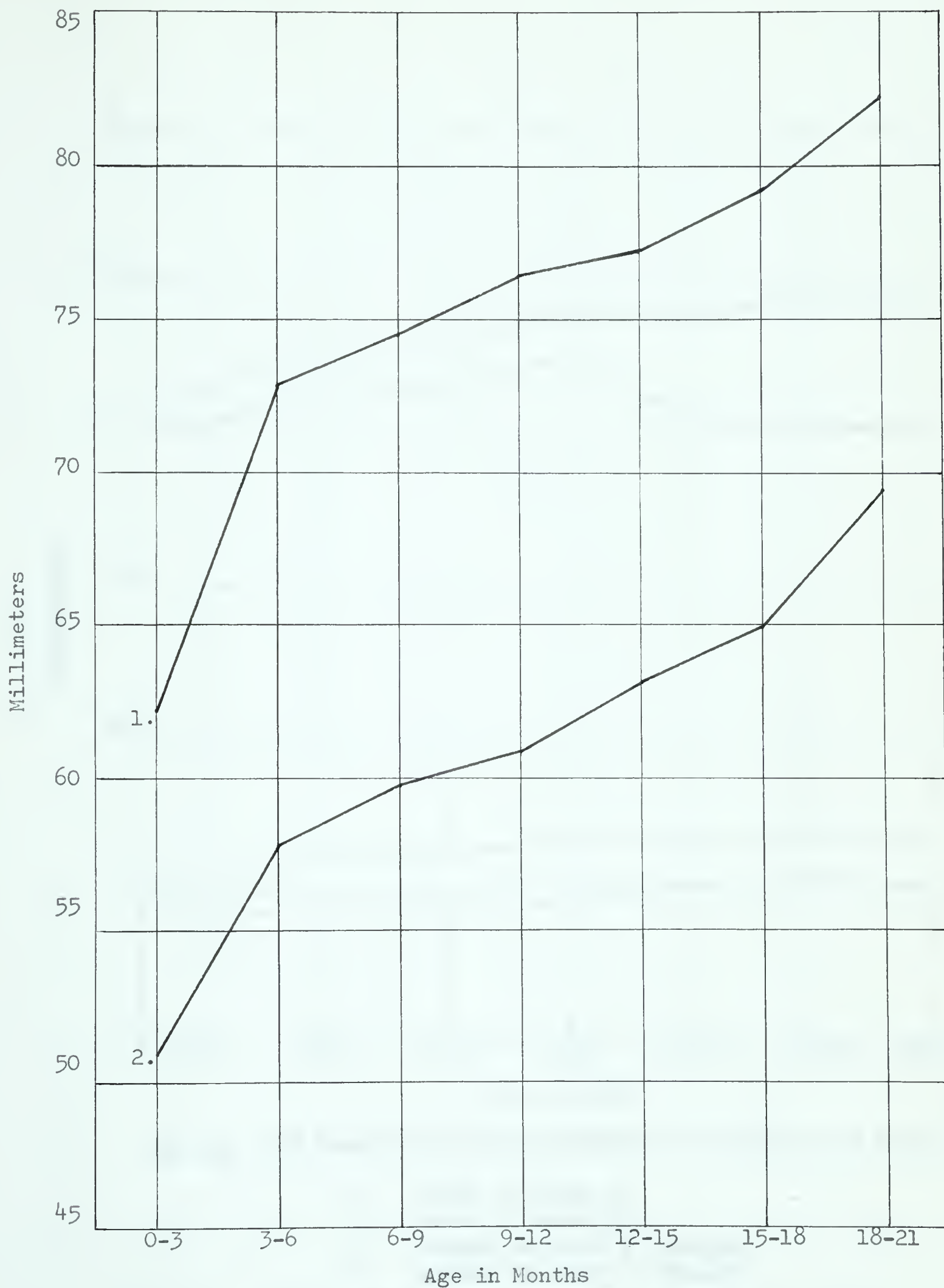


Fig. 28 . MEAN GROWTH MEASUREMENTS AT DIFFERENT AGE GROUPS

1. Palatal Arch Length.

2. Mandibular Arch Length.

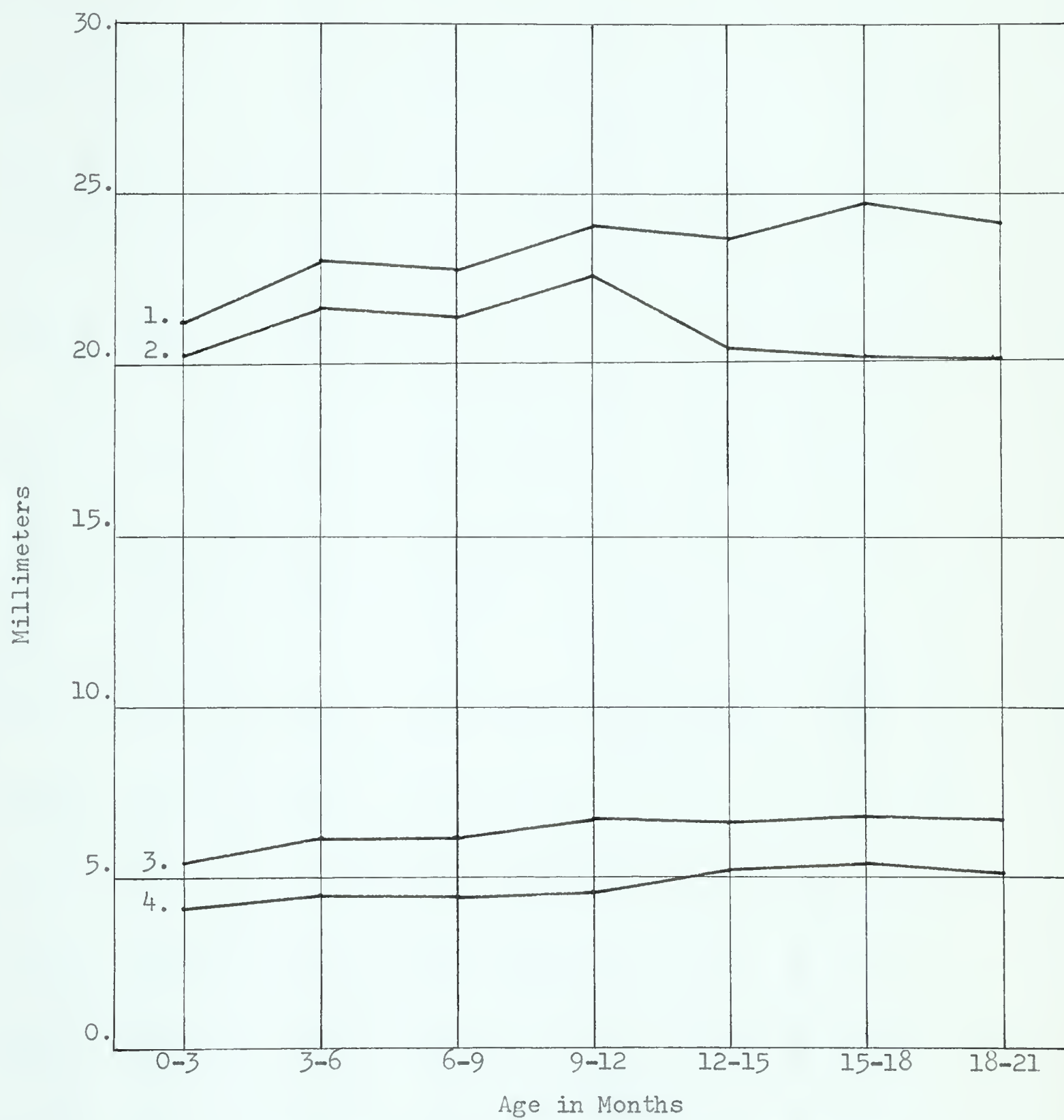


Fig. 29. MEAN PALATAL VAULT MEASUREMENTS AT DIFFERENT AGE GROUPS

1. Width at Point J.
2. Width at Point K.
3. Length at Point K. (Height)
4. Length at Point J. (Height)

TABLE 21

MEAN GROWTH MEASUREMENTS IN MILLIMETERS; AT DIFFERENT AGE GROUPS

		Age in Months																			
		0 - 3		3 - 6		6 - 9		9 - 12		12 - 15		15 - 18		18 - 21							
		n	$\bar{X}$	sd	n	$\bar{X}$	sd	n	$\bar{X}$	sd	n	$\bar{X}$	sd	n	$\bar{X}$	sd					
Anterior Palatal Width	7	22.4	.95	26	27.09	1.52	13	27.63	2.28	13	28.16	1.76	13	27.82	1.74	16	28.70	2.18	7	28.75	2.59
Maximum Palatal Width	7	30.25	.86	26	32.76	2.31	13	33.12	2.53	13	34.10	2.21	14	34.23	2.21	15	34.73	2.38	8	35.21	2.80
Posterior Palatal Width	7	27.43	1.23	25	29.71	1.66	13	29.73	2.07	13	30.94	2.33	14	31.93	2.14	14	31.63	2.59	8	32.51	2.18
Anterior Palatal Length	7	6.9	.68	25	8.29	.78	13	8.8	.87	13	8.9	1.08	14	9.1	1.16	14	9.5	1.04	8	9.3	1.02

Maximum Palatal Length	7	22.64	1.59	25	27.22	1.49	12	28.22	2.48	13	29.43	1.40	13	29.43	1.40	14	30.35	1.83	7	31.78	1.08
Palatal Arch Length	7	62.14	2.35	25	72.72	3.40	12	74.33	4.53	13	76.23	3.42	13	77.07	2.36	14	79.0	4.42	7	82.14	4.71
Anterior Mandibular Width	7	21.91	1.17	26	23.04	1.69	13	23.99	1.63	13	24.24	1.52	14	23.93	1.44	15	24.02	1.46	8	24.13	1.68
Posterior Mandibular Pad Width	7	28.65	.88	23	30.09	1.81	12	30.62	1.45	12	31.37	1.60	14	32.02	1.89	13	32.34	1.99	7	32.23	1.65
Posterior Mandibular Width	7	30.27	1.19	25	32.39	1.84	12	32.60	1.79	13	32.93	1.65	14	34.04	1.78	14	34.65	2.2	7	35.75	1.71
Mandibular Mid line Length	7	16.62	.93	25	19.98	1.54	12	21.06	1.73	13	21.93	2.19	14	22.92	1.65	14	23.85	1.49	7	25.90	2.04
Mandibular Arch Length	7	50.71	2.63	25	57.52	3.44	12	59.66	3.84	13	60.69	3.30	14	62.92	2.76	14	64.78	2.80	7	69.28	3.49

n = number

sd = standard deviation

$\bar{X}$ = mean

TABLE 22

MEAN PALATAL VAULT MEASUREMENTS IN MILLIMETERS AT DIFFERENT AGE GROUPS

Age in Months																					
Measurement	0 - 3		3 - 6		6 - 9		9 - 12		12 - 15		15 - 18		18 - 21								
Cord	n	$\bar{X}$	sd	n	$\bar{X}$	sd	n	$\bar{X}$	sd	n	$\bar{X}$	sd	n	$\bar{X}$	sd						
Palatal Height at J	5	4.04	.45	25	4.45	.36	13	4.38	.68	14	4.60	.60	10	5.22	.93	7	5.11	.94			
Palatal Height at K	5	5.40	.75	23	6.20	.78	13	6.22	.70	14	6.73	.79	11	6.62	.95	14	6.77	.63	8	6.60	.78
Palatal Width at J	5	21.38	1.93	25	23.18	.93	13	22.76	2.5	14	24.16	1.74	11	23.74	1.44	12	24.80	2.07	7	24.21	2.35
Palatal Width at K	5	20.28	1.51	25	21.74	1.90	13	21.48	2.05	14	22.72	1.97	12	20.52	1.91	14	20.31	2.14	8	20.20	1.64

n = number

 $\bar{X}$ = mean

sd = standard deviation

(B) Occlusal Relation

The antero-posterior measurements of occlusal relation (overjet) in the incisor and canine area are seen in Tables 23 and 24. The per cent overbite in the incisor area is seen in Table 25. Mean measurements are seen in Table 26. Anterior openings between the gum pads of the first cast in each series were recorded as being either present or absent, (Table 27).

TABLE 23

OCCLUSAL RELATION MEASUREMENTS IN THE INCISOR AREA
FOR DIFFERENT AGE GROUPS

Age in Months							
0 - 3	3 - 6	6 - 9	9 - 12	12 - 15	15 - 18	18 - 21	21 - 24
6.0	3.0	2.0	3.0	2.5	1.3	3.0	2.5
3.5	1.5	4.0	3.0	4.0	3.5	2.2	2.3
5.0	3.0	1.5	3.2	3.0	3.0	0.8	1.5
5.0	2.5	4.5	3.0	1.5	3.0	4.7	2.8
2.0	3.0	0.0	4.5	2.0	2.0	2.5	
	4.4	1.5	2.0	2.0	2.0	4.5	
	3.5	2.5	2.0	3.0	3.5	3.0	
	2.5	2.2	4.0	2.0	3.5		
	3.8	4.0	2.4	1.0	2.5		
	5.0		2.5	2.3	1.2		
	2.5		3.5		2.6		
	2.3				2.0		
	2.5				2.0		
	3.0				2.5		
	4.0						
	4.0						
	5.0						
	2.0						

Measured in millimeters

TABLE 24

OCCLUSAL RELATION MEASUREMENTS IN THE CANINE AREA

FOR DIFFERENT AGE GROUPS

Age in Months							
0 - 3	3 - 6	6 - 9	9 - 12	12 - 15	15 - 18	18 - 21	21 - 24
1.3	1.0	1.5	2.5	3.5	2.5	2.0	1.5
1.0	2.5	1.0	0.0	1.5	1.5	2.5	3.4
0.5	1.0	1.0	1.5	0.0	3.7	3.7	3.4
0.0	3.5	-0.5	0.0	2.5	1.0	0.5	4.2
0.0	0.0	3.5	0.0	0.0	2.0	2.0	
	0.0	2.0	2.5	1.0	2.0	3.8	
	0.0	2.0	1.7	3.5	3.5		
	1.0	2.3	1.5	3.0	1.5		
	2.0	1.0	0.0	1.5	0.5		
	0.0		0.0	4.2	2.3		
	0.0		0.5	1.4	4.0		
	1.8		1.0	3.0	3.0		
	0.0				2.6		
	3.0				2.4		
	1.0				3.5		
	0.0						
	0.5						
	0.0						
	0.0						

Measured in millimeters

TABLE 25

PERCENTAGE OVERBITE FOR DIFFERENT AGE GROUPS

Age in Months							
0 - 3	3 - 6	6 - 9	9 - 12	12 - 15	15 - 18	18 - 21	21 - 24
	40.0	100.0	50.0	75.0			100.0
		90.0	100.0	80.0	100.0		50.0
		50.0	60.0	50.0	100.0		40.0
		75.0	50.0	70.0	60.0		75.0
			65.0	90.0	70.0		
			100.0	70.0			
			60.0	80.0			
			75.0	50.0			
			30.0	70.0			
			60.0	75.0			
				80.0			
				100.0			
				90.0			
				75.0			
				70.0			
				60.0			

TABLE 27

INCIDENCE OF PRE-ERUPTION ANTERIOR OPENING

	Number	Percent
Opening	25	71.5
No Opening	10	28.5
Total	35	100

TABLE 26

MEAN MEASUREMENT OF OCCLUSAL RELATION AND PERCENTAGE OVERBITE

		Age in Months																							
		0	-	3	3	-	6	6	-	9	9	-	12	12	-	15	15	-	18	18	-	21	21	-	24
Antero- Posterior Relation in Incisor Area	n	$\bar{X}$	n	$\bar{X}$	n	$\bar{X}$	n	$\bar{X}$	n	$\bar{X}$	n	$\bar{X}$	n	$\bar{X}$	n	$\bar{X}$	n	$\bar{X}$	n	$\bar{X}$	n	$\bar{X}$	n	$\bar{X}$	n
		5	4.2	18	3.2	9	2.4	12	3.0	11	2.2	15	2.5	7	3.0	4	2.2	15	2.5	7	3.0	4	2.2	15	2.5
Antero- Posterior Relation in Canine Area	5	0.7	18	0.8	9	1.5	12	0.9	12	2.1	15	2.4	6	2.4	4	3.1									
Percentage Overbite	*		*		1	40	4	78	10	65	16	74	4	82	4	66									

* Not measurable due to incomplete eruption of teeth

C. Tooth Position and Eruption Times

(a) Tooth Position

Only the results from the first 2 years of this 3-year study are being reported. The total number of erupted deciduous teeth is relatively small. For many children deciduous teeth were present in only the third set of casts and in several cases not at all. Thus, changes in tooth position between age groups could not be made.

Measurements of tooth position were made within 6 months after individual teeth erupted (Tables 28, 29, 30). The means were then calculated (Tables 31, 32, 33).

(b) Eruption Times

From the 21 eruption charts returned, the mean eruption times for the deciduous teeth were calculated (Table 34). Boys and girls were grouped together, as were right and left sides. No eruption dates were returned for the second deciduous molars in the period under study for this report. The order of eruption is presented in Figure 30.

TABLE 28

TABULATED MEASUREMENT OF THE ANGLES OF THE DECIDUOUS
INCISORS TO THE MID-LINE: MEASURED WITHIN 6 MONTHS
AFTER ERUPTION

Maxilla				Mandible			
Right		Left		Left		Right	
A	B	A	B	A	B	A	B
82	39	74	37	90	62	89	54
70	58	60	54	88	42	96	62
93	62	87	56	90	70	90	67
88	33	79	29	102	72	99	85
85	55	73	56	79	81	68	38
75	85	63	81	102	32	108	47
80	44	73	39	90	33	81	63
90	54	73	70	96	63	91	58
84	57	79	65	98	70	95	50
80	68	89	57	88	67	73	69
87	22	73	59	94	44	87	55
90	79	81	22	88	60	87	67
85	40	77	67	105	52	95	72
83	55	84	38	83	74	85	60
86	58	86	60	100	68	103	42
80	60	80	72	110	74	117	32
90	46	78	62	91	31	84	52
77	58	76	30	97	46	90	39
76	36	65	55	92	37	84	58
87	32	75	29	73	56	82	56
87	55	89	32	108	50	110	78
70	46	65	42	89	59	93	70
66	47	62	35	94	62	92	67
73	62	72	55	93	77	91	
90	45	81	58	88		93	
76		61	43	88		92	
67		73		85		78	
				92		90	
				97		105	
				91		93	

Measured in degrees

TABLE 29

TABULATED MEASUREMENTS OF THE DISTANCE BETWEEN THE
DECIDUOUS INCISORS AND THE MID-LINE: MEASURED WITHIN
6 MONTHS AFTER ERUPTION

Maxilla				Mandible			
Right		Left		Left		Right	
A	B	A	B	A	B	A	B
3.5	9.2	3.7	8.5	2.0	6.0	2.0	6.5
3.5	9.4	3.3	9.0	1.5	7.0	2.0	6.0
4.2	9.5	4.2	9.2	2.0	9.2	2.0	6.7
4.0	8.5	3.6	8.2	2.0	6.0	2.0	6.5
3.3	9.3	3.0	9.2	2.5	6.2	2.0	9.3
4.0	7.4	4.0	9.0	2.1	6.6	2.0	6.2
3.5	9.0	3.0	9.3	1.8	6.0	1.8	6.5
3.0	9.1	3.0	8.6	2.1	6.4	2.1	6.3
4.0	8.7	4.0	8.5	2.1	6.3	2.2	6.4
3.8	9.2	3.3	9.1	2.0	6.1	2.0	6.1
3.5	9.6	3.5	8.7	2.0	6.6	2.4	6.2
3.7	8.8	3.7	9.0	2.0	5.9	1.8	6.5
3.3	9.3	3.3	10.0	2.3	6.6	2.3	6.0
3.6	9.2	3.6	9.8	2.0	5.8	2.0	6.0
3.9	9.3	3.9	9.0	2.1	5.3	1.9	6.3
3.7	8.1	3.3	9.0	1.9	6.0	1.9	5.4
3.7	8.8	3.7	9.0	2.0	6.6	2.0	6.0
3.4	9.4	3.4	8.2	1.8	6.6	2.0	6.2
3.8	9.3	3.8	8.7	2.2	6.7	2.2	6.5
3.6	8.0	3.6	8.8	2.0	6.1	2.0	7.6
3.6	9.3	3.6	9.2	2.3	6.8	2.5	6.7
3.7	8.6	3.7	9.0	2.4	6.3	2.3	6.1
4.3	10.5	4.3	8.2	2.0		2.0	6.6
2.8	9.2	2.8	9.3	2.4		2.4	6.2
				2.1		2.0	
3.7		3.7	9.8	2.7		2.5	
3.4		3.4	10.5	2.2		2.2	
4.1		4.2	9.0	1.9		1.9	
3.5		3.5		2.1		2.0	

Measured in millimeters

TABLE 30

TABULATED MEASUREMENTS OF THE SPACE BETWEEN DECIDUOUS TEETH: MEASURED
WITHIN 6 MONTHS AFTER ERUPTION

	Centrals	Centrals -		Laterals -		Canines -		1st. Molars -	
		Laterals		Canines		1st. Molars		2nd. Molars	
		R	L	R	L	R	L	R	L
Maxilla	1.2	0.5	0.5	1.5	1.5	1.5	1.0	0.7	1.4
	0.7	1.2	0.6	1.7	1.7	1.5	1.5	0.3	0.3
	2.9	0.7	0.7	1.8	1.3	1.8	1.1	1.4	1.4
	0.0	0.7	0.3	1.7	1.5	1.6	1.3		
	0.7	0.5	0.5	1.7	1.7	1.6	1.9		
	1.0	0.0	0.5	1.7	2.0				
	1.0	0.6	0.0	1.7					
	0.0	0.7	0.0						
	1.6	1.0	0.5						
	0.7	1.2	1.0						
	2.3	1.0	1.0						
	1.7	0.0	1.4						
	0.7	1.0	1.4						
	2.2	1.2	0.0						
	0.0	0.0	0.9						
	0.3	0.0	0.8						
	0.7	1.2	0.5						
	2.3	0.7	0.4						
	1.7	0.5	1.4						
	1.4	1.0	0.2						
	1.6	0.0	1.0						
	1.9	0.5	1.0						
	0.4	0.8	0.0						
	0.9	0.9	0.5						
	1.2		0.6						
	1.2		0.8						
Mandible	0.9	1.0	1.0	0.4	0.2	1.3	1.1	1.5	1.7
	0.5	0.0	0.0	1.0	0.5	1.5	1.5	2.0	1.5
	-0.7	0.0	0.0	0.7	0.5	2.1	2.0	1.2	1.6
	-2.0	0.9	0.6	1.2	0.9	1.2	1.2		
	0.5	0.0	0.0	0.3	0.5	1.9	1.7		
	-0.5	0.5	0.5	0.3	0.3	1.9	1.9		
	0.7	0.4	0.5	0.8	0.6	2.0	2.1		
	0.0	0.6	0.5						
	-0.1	0.5	0.6						
	-0.2	0.0	0.5						
	0.6	1.0	0.6						
	-0.4	0.0	0.9						
	0.7	0.7	0.7						
	0.0	0.0	1.0						
	-0.4	1.0	0.0						
	-0.5	0.7	0.7						
	0.5	1.1	0.9						
	-0.5	0.0	0.0						
	0.7	0.7	0.6						
	-0.3	0.8	0.8						
	1.2								
	0.8								
	0.5								
	0.7								
	0.0								
	0.8								
	0.6								
	0.7								

A minus denotes crowding. Measured in millimeters.

TABLE 31

MEAN ANGLE OF INCISORS TO THE MID-LINE

Incisors	Maxilla		Mandible	
	n	$\bar{X}$	n	$\bar{X}$
Right Lateral	25	51.85	23	58.30
Right Central	27	81.37	30	91.36
Left Lateral	26	50.11	24	57.58
Left Central	27	75.11	30	92.70

TABLE 32

MEAN DISTANCE FROM INCISORS TO THE MID-LINE

Incisors	Maxilla		Mandible	
	n	$\bar{X}$ mm.	n	$\bar{X}$ mm.
Right Lateral	24	9.02	24	6.45
Right Central	28	3.64	29	2.08
Left Lateral	27	9.02	22	6.41
Left Central	28	3.75	28	2.08

TABLE 33

MEAN SPACE BETWEEN THE DECIDUOUS TEETH

Maxilla				Mandible				
Centrals				n = 26	$\bar{X}$ = 1.16	n = 28	$\bar{X}$ = 0.14	
				R	L	R	L	
	n	$\bar{X}$	n	$\bar{X}$	n	$\bar{X}$	n	$\bar{X}$
Centrals - Laterals	24	0.66	26	0.63	20	0.49	20	0.52
Laterals - Canines	7	1.68	6	1.61	7	0.67	7	0.50
Canines - 1st. Molars	5	1.60	5	1.36	6	1.78	7	1.64
1st. - 2nd. Molars	3	0.80	3	1.03	3	1.56	3	1.60
Measured in millimeters								

TABLE 34

MEAN ERUPTION TIMES OF THE DECIDUOUS TEETH:

RECORDED IN MONTHS

Tooth. Right and Left	Maxilla			Mandible		
	n	$\bar{X}$ months	Range	n	$\bar{X}$ months	Range
A	40	9.7	4.8 - 13.4	42	8.4	3.4 - 13.0
B	40	11.6	4.3 - 16.9	32	12.2	4.4 - 16.3
C	15	17.3	12.0 - 24.0	13	16.6	10.5 - 24.4
D	26	15.8	12.1 - 21.4	26	15.7	10.1 - 21.6
E	0	-	-	0	-	-

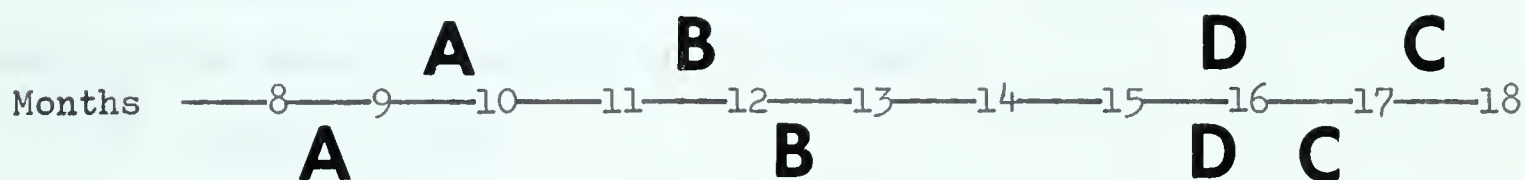


Fig. 30.

ORDER OF ERUPTION FOR THE DECIDUOUS TEETH,

EXCLUDING SECOND MOLARS

DISCUSSION

This research has involved a study of four aspects of dental development during the age period 3 months to 2 years.

The four aspects are:

- A. Changes in dimension of the maxillary and mandibular dental arches.
- B. Changes in dimension of the palatal vault.
- C. Occlusal relation of the dental arches.
- D. Eruption and movement of the deciduous teeth.

A. Changes in Dimension of the Maxillary and Mandibular Arches

For the purpose of discussion the changes will be described as affecting the anterior and posterior aspects of the arches during the 0 - 6 months period and the 6 - 21 months period. The changes due to growth during these two periods were as follows:

1. Anterior Arch

	<u>Increase in Millimeters</u>	
	<u>0-6 months</u>	<u>6-21 months</u>
Anterior palatal width	1.69	1.66
Anterior palatal length	1.39	1.01
Anterior mandibular width	1.13	1.09

There appears to be little growth in the anterior region of the maxillary and mandibular arches from birth to 21 months. One half of the total increase occurred prior to 6 months of age and most of the

remaining increase took place from 6 - 12 months (Fig. 27). The total increase in anterior width was greater in the maxillary arch (3.35mm.) than in the mandibular arch (2.22 mm) which may be a reflection of growth due to the eruption time of the maxillary deciduous lateral incisors. The fact that the actual increase in the dimension of the anterior region of the arches is slight indicates that at birth the anterior arch is almost adequate in size to accommodate the deciduous incisors, which begin to erupt at about 7 - 9 months of age^{26,27}:

Concerning the growth of the alveolar process, one might ask whether the increase in growth is the result of eruptive forces or whether the growth is unrelated to the eruption of the teeth. The findings in this study appear to support the former, at least in the anterior region of the arches, there being a slightly greater increase in the maxillary arch than in the mandibular arch. The increased growth in the anterior region of the maxillary arch may be associated with the earlier eruption of the maxillary deciduous lateral incisors compared to the mandibular laterals^{26,27}. The slight growth spurt in both arches from birth to 6 months of age could be due to the eruptive forces of the four deciduous incisors which are usually the first deciduous teeth to erupt. Cases of complete anodontia also support the hypothesis that alveolar bone growth is associated with the development of the teeth, because, in anodontia, the alveolus is almost absent^{28,33}.

The basic question is whether the growth spurt is associated with the presence of the deciduous teeth and their eruptive forces or whether it is completely independent. Possibly the growth spurts and eruptive processes are genetically determined and independent of each other. Garn, et al³⁴, have shown that 90% of the variations in tooth formation and movement timing appears to be genetically determined.

2. Posterior Arch

Except for the posterior mandibular pad width at 0 - 6 months, all the posterior arch dimensions increased more than the anterior arch dimensions.

	<u>Increase in Millimeters</u>	
	<u>0-6 months</u>	<u>6-21 months</u>
Posterior mandibular width	2.12	3.36
Maximum palatal width	2.51	2.45
Posterior palatal width	2.28	2.80
Posterior mandibular pad	1.44	2.14
Maximum palatal length	4.58	4.56
Mandibular mid-line length	3.36	5.92
Palatal arch length	10.58	9.42
Mandibular arch length	6.81	11.78

It is most likely that the active growth in the posterior region from birth to 21 months, takes place to provide space for the eruption of the deciduous molars; at birth the space available for the molars is quite inadequate, necessitating the observed active growth spurt.

Approximately one-half of the maxillary arch growth occurred prior to 6 months, while in the posterior region of the mandibular arch a smaller percentage of the total growth occurred prior to six months. These figures indicate that the posterior mandibular arch growth lags behind the posterior maxillary arch growth from birth to 6 months of age. However, from 6 to 21 months posterior mandibular growth speeds up and for some dimensions even passes the posterior maxillary growth. The increased rate of growth in the posterior region of the mandibular arch may be associated with the eruption of the mandibular first deciduous molars which precedes the eruption of the maxillary first deciduous molars.

It appears that arch growth is closely related to the eruptive forces of the teeth. To study this possibility more closely, growth would have to be related to eruption times, rather than chronological age. Recently, Moorrees²⁹ reported such a study on the development of the permanent dentition. He found tooth emergence and eruption to be more suitable as parameters of dental development than chronological order for defining the changes in arch dimensions for the average child. Continued follow-up of the cases in the present study will provide comparable data for analysing development of the deciduous dentition.

B. Changes in Dimension of the Palatal Vault See Fig. 29, page 83.

1. Palatal Vault Width

	<u>Increase in Millimeters</u>	
	<u>0-12 months</u>	<u>12-21 months</u>
Vault width at J.	2.78	.05
Vault width at K.	2.44	-2.52

At point J and at point K (10 mm. anterior to J), there was an irregular increase in the width of the palatal vault from birth to 12 months of age; irregular, because at 9 months there was a slight decrease. This increase may be due to growth at the mid-palatine suture, apposition and resorption of the alveolar process, or most likely, a combination of both²⁰. The exact mechanism is not understood.

From 12 months to 21 months there was considerable difference in growth patterns at the two points. At point J there was no change in the vault width, indicating a cessation of growth. However, at point K, from 12 to 21 months, there was a 2.52 mm. decrease in the vault width, most of which occurred from 12 to 15 months. The reason for the decrease is

not known. However, it may be due to increased width of the alveolar process preceding the eruption of the first deciduous molars which might be reflected in a lingual bulging of the process. This bulging is apparent on direct observation of the dental casts. Point K is adjacent to the first deciduous molar area.

2. Palatal Vault Height

	<u>Increase in Millimeters</u>	
	<u>0-3 months</u>	<u>3-21 months</u>
Vault height at J	.41	.66
Vault height at K	.80	.40

There was very little increase in the height of the palatal vault from birth to 21 months of age, measured at point J and K. The pattern of growth was quite similar at both points; however, at point K there appeared to be a slightly more active growth rate from birth to three months of age.

Lebert²⁰ observed no increase in palatal vault height in a serial study of children from 5 to 18 years of age. He used as his two references, a line drawn from the distal surface of the 2nd. deciduous molar perpendicular to the median palatal raphe, and a point 10 millimeters anterior (Fig. 8). It appears, from the present study, that the palatal vault height is almost established at birth, there being only a minimal increase during the first two years of life. Although the reference points in this study are not exactly the same as Lebert's, they closely approximate Lebert's. It is reasonable, therefore, to conclude that the palatal vault height is established prior to age one or even before and remains relatively stable to age 18.

C. Occlusal Relation of the Dental Arches

Because of the difficulty in articulating edentulous casts with a wax bite, the total cases recorded in Tables 23 and 24 are less than the total number of cases in the entire study. The eruption of the first deciduous molars aided considerably in establishing occlusion.

1. Anterior Posterior Relation of the Dental Arches

In the incisor area the mean maxillary overjet decreased from 4.2 mm. at 0 - 3 months, to 2.2 mm. at 21 - 24 months. However, in the canine area the mean measurements increased from 0.7 mm. at 0 - 3 months to 3.1 mm. at 21 - 24 months. These findings indicate that the forward growth of the mandible is greater than the forward growth of the maxilla. The accelerated growth of the mandible would decrease the maxillary overjet in the incisor area, and increase the distance between the maxillary and mandibular lateral sulcus points in the horizontal plane. These findings are similar to those of Clinch¹⁷ and Sillman¹⁸.

2. Anterior Opening Between the Occluded Gum Pads.

An anterior opening was present in 24 out of 35 cases (71.5 percent). The importance of the anterior opening is not known. Clinch¹⁷ believed that the lack of an opening would result in malocclusion, while Sillman¹⁵ believed the presence or absence of the anterior opening was not a factor in the developing occlusion.

It may be that the anterior opening assists the infant in sucking. It is known, that at birth, the tongue is large in relation to both the maxilla and the mandible and particularly to the mandible. During swallowing

the tongue spreads between the gum pads. Moyers²⁸ believes that persistence of such infantile swallowing may result in malocclusion. It is possible that the inherited size and the activity of the tongue, particularly the former, are factors in determining the presence or absence of pre-eruptive anterior opening. When the children involved in the present study reach 3 years of age, a correlation analysis should be done to determine whether any relationship exists between retained infantile swallowing, pre-eruptive anterior opening and malocclusion.

3. Percent Overbite

There was an increase in overbite from 6 - 9 months to 18 - 21 months. However, the numbers involved are too small to be conclusive. Also, the individual variations are large. The range in overbite was from 50 to 100 percent in the 12 - 15 months age group. Continuing eruption of the incisors to occlusion with their antagonists may account for the increase in overbite. Quigley and Castaldi³⁰ found that 30.9% of 498 children, ages 6 - 12 in two Alberta communities had overbites exceeding 50%. In the present study, a pre-eruptive anterior opening between the gum pads was absent in 28.5% of the cases. These findings suggest that an excessive anterior overbite may be related to the lack of a pre-eruptive anterior opening between the gum pads. (See Anterior Opening Between the Occluded Gum Pads, above). Clinch¹⁷ believed the absence of a pre-eruptive anterior opening was a factor in the development of excessive anterior overbites.

D. Eruption of Deciduous Teeth and Movement After Eruption

1. Eruption of the Deciduous Teeth

The mean deciduous eruption times obtained from the present study (which exclude second molars because of the age of the children) are similar to those obtained in other studies ^{26, 27}. (Table 34, Fig. 30). There was a wide range in eruption times, indicating large individual variation (Table 26). When the children involved in the present study reach 3 years of age, the individual eruption dates of the deciduous teeth may be used to study the correlation of eruption with ridge growth as suggested previously in this discussion.

2. Alteration in Tooth Position

Because of the age of the children, attempts to measure changes in tooth position were not considered justified. However, means were established for tooth position shortly after eruption. Using these means as a base, alteration in tooth position can be observed when the children are older.

(a) Angles of Deciduous Incisors to the Mid-Line

The mean angles of the deciduous incisors to the mid-line tend to follow the arch form (Fig. 31). The form of the anterior segment in the mandibular arch is relatively flat and the mandibular central incisors had a mean angle to the mid-line of 91.36° right and 92.70° left. However, in the maxillary arch there is a greater arch curvature in the anterior segment, and a smaller angle was found between the maxillary deciduous incisors and the mid-line (81.73° right and 75.11° left). The mean angles of the mandibular lateral incisors to the mid-line (58.30° right and 57.58° left) were only slightly greater than the maxillary laterals (51.85° right and 50.11° left).

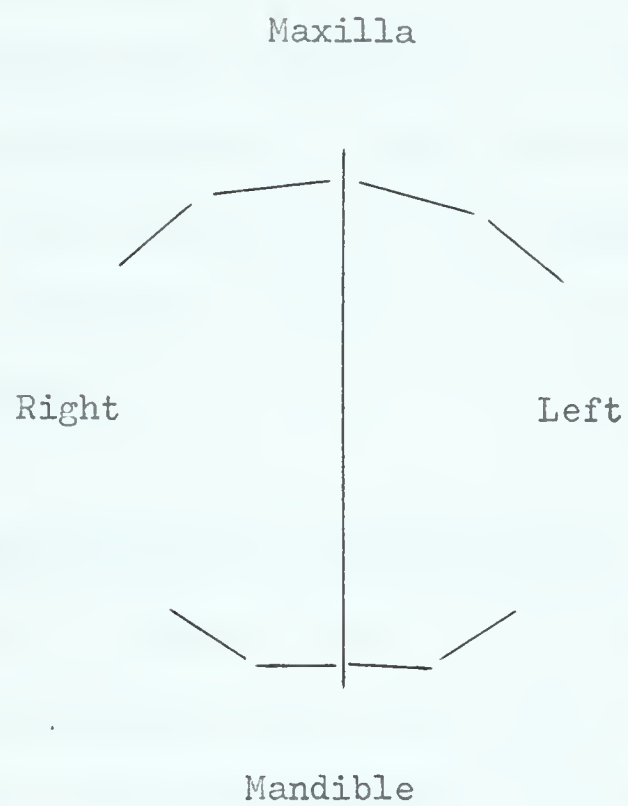


Fig.31. Mean Angle of Deciduous Incisors to the Mid Line
(Measured from 0 - 6 Months After Eruption)

(b) Distance from the Deciduous Incisors to the Mid-Line

The mean distances between the middle of the labial surface of the deciduous incisors and the mid-line are present in Table 32. The mean maxillary measurements were larger than the mean mandibular measurements. This is probably due to the maxillary incisors being larger than the mandibular incisors and the space between the maxillary teeth being greater.

(c) Space Between the Deciduous Teeth

Except for the space between the first and second molars, the space between the maxillary deciduous teeth exceeded the corresponding spaces between the mandibular deciduous teeth (Table 33). Arnold³¹ found that the interdental spacing between the deciduous teeth decreases continually with age. However, Moorrees²² observed that the amount of interdental space in the deciduous dentition did not increase after 3 years of age. Baume³² observed no change in spacing from age 3 to age 6.

The mean space between the mandibular central incisors was only .41 mm. with one-third of the cases exhibiting crowding. This was the only area in which crowding occurred. In several cases the mandibular central incisors were crowded, but there was space between the centrals and laterals. It is not known why this occurs. However, the crowding of the mandibular deciduous centrals may be associated with the small size of the mandible at birth, causing rotation of the tooth buds within their bony crypts. It will be interesting to see if the crowding will persist, increase or decrease with age.

SUMMARY AND CONCLUSION

The purpose of this research was to find a suitable method for studying the growth and development of the human dentition during the first two years of life, and having established such a method, to study in detail:

1. Changes in dimension of the maxillary and mandibular dental arches.
2. Changes in dimension of the palatal vault.
3. Occlusal relation of the dental arches.
4. Eruption and movement of the deciduous teeth.

The following conclusions can be made:

1. Suitable dental casts for detailed growth studies can be obtained from children aged 0 - 2 years by means of commonly available alginate dental impression materials and without the use of sedation or general anesthesia.
2. There is a slight increase in the size of the anterior portion of the dental arches from birth to 12 months, and little or no change in size from 12 to 21 months.
3. The increase in size of the anterior portion of the dental arches was greater in the maxilla than in the mandible.
4. The posterior portion of the dental arches increases in size to a much greater extent than the anterior portion of the arches, from birth to 21 months.

5. The posterior mandibular arch growth lags behind the posterior maxillary arch growth from birth to six months of age. However, from six to twenty-one months, the posterior mandibular arch growth speeds up and for some dimensions even passes the posterior maxillary arch growth.
6. The observed growth changes in the maxillary and mandibular dental arches appear to be associated with eruption of the deciduous teeth.
7. Palatal vault height increases only slightly from birth to twelve months and very little thereafter, indicating that palatal vault height is established very early in life.
8. Palatal vault width, measured at the posterior border of the arch, increases from birth to twelve months of age and then remains relatively constant.
9. In the first deciduous molar area the vault width also increases from birth to twelve months, then suddenly decreases to near the birth measurement, and remains there through to twenty-one months. The decrease is believed due to the buccal lingual bulging of the alveolar ridge resulting from the erupting first deciduous molar.
10. At birth the mandibular arch is posterior to the maxillary arch when the gum pads are in contact. This posterior relation of the mandibular arch continually decreases with age to twenty-one months.

11. There was an anterior opening between the occluded gum pads in 71.5% of the cases studied. The absence of this anterior opening may be a factor in the development of abnormal occlusion, and for this reason, it is important to follow-up the cases in the present study.
12. Although the number of cases reported in this study is small, the eruption times of the deciduous teeth varied greatly. This finding agrees with previous studies.
13. Incisal edges of newly erupted deciduous incisors tend to follow the curvature of the anterior portions of the dental arches.
14. The spaces between maxillary deciduous teeth are greater than the spaces between the mandibular deciduous teeth. In one-third of the cases studied, the mandibular deciduous incisors were crowded.

Mean values have been established for:

- (a) Angle of the deciduous incisors to the mid-line.
- (b) Distance from the deciduous incisors to the mid-line.
- (c) Space between the deciduous teeth.

Using these values, alterations in deciduous tooth positions can be observed at a later date.

The present study is but a part of a larger study intended to provide more information about the development of the human dentition in the early period of life. Several growth trends have been established, but the significance of these trends in the development of the dentition cannot be evaluated until further study has been made of subsequent changes in the dentition, which accompany increased age.

BIBLIOGRAPHY

1. Tanner, J. M. Growth at Adolescence. 1st ed. Springfield, Ill.: Charles C. Thomas, 1955.
2. Scammon, R. E. "The First Seriatim Study of Human Growth," Am. J. Phys. Anthropol., **10:329**, 1927.
3. Appleton, J. L. T., English, J. A., Levy, B. M., McFall, T. A. Some Problems in Oral Health, p. 46, Washington, D. C.: Jones Composition Company, 1962.
4. West, C. M. "The Development of the Gums and Their Relationship to the Deciduous Teeth in the Human Foetus," Contributions to Embryology, No. 78, (Carnegie Institution of Washington, Publication 361), 1925.
5. Friel, S. "Occlusion: Observations on its Development from Infancy to Old Age," Ortho. and Oral Surg., Int. Jnl., **13:322**, 1927.
6. Ashley-Montagu, M. F. "The Form and Dimensions of Palate in the New-Born," Orthodia. and Dent. for Children, Int. Jnl., **20:694**, 810, 1934.
7. Alkan, L. "Gewisse Formen des Harten Gaumens und ihre Entstehung," Arch. F. Laryng. U. Rhim., **10:441**, 1960.
8. Denzer, B. S. "The Size of the Infantile Palate," Brit. Den. Jnl., **43:25**, 1922.
9. Katz, J. "Ueber die Gaumenform beim Neugeborenen," (Unpublished Inaugural Dissertation in the Library of the Anatomical Institute, p. 1-23), Frankfurt: Frankfurt University, 1923.
10. Peyton, W. T. "The Dimensions and Growth of the Palate in the Normal Infant with Gross Maldevelopment of the Upper Lip and Palate," Ortho., Oral Surg. & Rad., Int. Jnl., **17:705**, 1931.
11. Frank, G. "Ueber Wachstum und Verbildungen des Kiefers und der Nasenscheidwand auf Grund vergleichender Kiefer-Messungen und experimenteller Untersuchungen uber Knochenwachstum," Ztschr. F. Laryng., **10:187**, 1922.
12. Clinch, Lilah M. "Variations in the Mutual Relationships of the Maxillary and Mandibular Gum Pads in the Newborn Child," Orthodia. and Dent. for Children, Int. Jnl., **20:359**, 1934.
13. Goldstein, M. S. and Stanton, F. L. "Changes in Dimensions and Form of the Dental Arches with Age," Orthodia. and Dent. for Children, Int. Jnl., **21:357**, 1935.

14. Stanton, F. L., Fish, G. D., Ashley-Montagu, M. E. "Description of Three Instruments for Use in Orthodontic and Cephalometric Investigations with Some Remarks on Map Construction," J. D. Res., 11:885, 1931.
15. Sillman, J. H. "Relationship of Maxillary and Mandibular Gum Pads in the Newborn Infant," Am. Jnl. Orthodics. and Oral Surg., 24:409, 1938.
16. Bakwin, H. and Bakwin, R. M. "Form and Dimensions of the Palate During the First Year of Life," Ortho. and Oral Surg., Int. Jnl., 22:1018, 1936.
17. Clinch, L. M. "Serial Models of Two Cases of Normal Occlusion between Birth and Four Years," D. Record., 60:323, 1940.
18. Sillman, J. H. "Development of Occlusion: Serial Study from Birth to Seven Years," J. 2nd Dist. D. Soc. (N.Y.), 31:153, Apr., 1945.
19. Bambha, J. K. "Longitudinal Study of Growth of the Face and Cranium During Preschool Years," J. Canad. D. A., 27:714, Nov. 1961.
20. Le Bret, L. "Growth Changes of the Palate," J. D. Res., 41:1391, Nov. - Dec., 1962.
21. Korkhaus, G. "A New Orthodontic Symmetrograph," Ortho., Oral Surg. and Rad., Int. Jnl., 16:40, 1930.
22. Moorrees, C. F. A. The Dentition of the Growing Child. Harvard University Press, 1959.
23. Sillman, J. H. "Dimensional Changes of the Dental Arches: Longitudinal Study from Birth to Twenty-five Years," Am. J. Orthodont., 50:824, Nov. 1964.
24. Heckmann, U., Hiecke, R. "Development of the Deciduous Dentition in 102 Children up to Two and One-half Years," Deutsche Zahnarztliche Zeitschrift, 18:1208, 1963.
25. Meredith, H. V. "Order and Age of Eruption for the Deciduous Dentition," J. D. Res., 25:43, Feb., 1946.
26. Meredith, H. V. "Chart on Eruption of the Deciduous Teeth for the Pediatricians Office," J. Pediatrics, 38:482, No. 4, April, 1951.
27. Lysell, L., Magnusson, B., and Thilander, B. "Time and Order of Eruption of the Primary Teeth: A Longitudinal Study," Odont. Revy., 13:217, No. 3, 1962.
28. Moyers, R. E. Handbook of Orthodontics. Chicago: The Year Book Publishers, 1959.
29. Moorrees, C. F. A., Reed, R. B. "Changes in Dental Arch Dimensions Expressed on the Basis of Tooth Eruption as a Measure of Biologic Age," J. D. Res., 44:129, Jan. - Feb., 1965.

30. Castaldi, C. R., Quigley, U. A., and Zacherl, W. "The Edmonton Dental Health Survey: A Survey of the Incidence of Malocclusion," (Unpublished), 1962.
31. Arnold, E. "A Study of the Significance of the Interdental Spacing of the Primary Dentition," (M. S. Thesis, Horance H. Rockham School of Graduate Studies), Ann Arbor: University of Michigan, 1954.
32. Baume, L. J. "Physiological Tooth Migration and its Significance for the Development of Occlusion," J. D. Res., 29:123, 331, and 338, 1950.
33. Sicher, H. "Oral Anatomy". Saint Louis, C.V. Mosby Co., 1965, p.129.
34. Garn, S.M., Lewis, A. B., and Kerewsky, R. S. "Genetic, Nutritional, and Maturational Correlates of Dental Development," J. D. Res., 44:228, Jan. - Feb., 1965.

OTHER READING

1. Baume, L. J. "Relationship between Jaw Growth, Tooth Development, and Tooth Eruption," J. D. Res., 30:502, Aug. 1951. Abstract.
2. Belger, Ilhan. "Dentition Stages with a Distinction of Maxillary and Mandibular Development," New York Univ. J. Dent., 14:27 - 31, Oct. 1955.
3. Boller, R. J. "Fetal Morphogenesis of the Human Dentition," J. Den. for Children, 31:67 - 97, 2nd Quart, 1964.
4. Brash, J. C. "Comparative Anatomy of Tooth Movement during Growth of the Jaws," D. Record, 73:460 - 476, May 1953.
5. Brodie, A. C. "Growth of the Jaws and the Eruption of the Teeth," Oral Surg., Oral Med. and Oral Path., 1:334 - 341, April 1948.
6. Dixon, A. D. "Early Development of the Mandible," D. Practitioner, 3:331 - 336, July 1953.
7. Frieband, Benjamin. "Growth of the Palate in the Human Fetus," J. Den. Res., 16:103 - 122, 1937.
8. Henriques, A. D. "Correlative Study of Palatofacial Growth using the Cephalometric and Roentgenographic Cephalometric Techniques," Am. J. Orthodont., 41:152 - 154, 1955. Abstract.
9. Junghams, J. A. "Study of the Growth and Development of the Anterior Portion of the Mandible between Ages of Three and Sixteen," J. Soc. D. Rec., 4:7 - 14, May 1955.
10. Orban, B. J. Oral Histology and Embryology. The C. V. Mosby Company, 4th edition, page 301. 1957.
11. O'Reilly, T. X. "Deciduous Dental Arch Widths and Widths of the Face in Early Childhoos," Am. J. Orthodont., 37:698 - 705, September 1951.
12. Roche, A. F., Barkla, D. H., and Maritz, J. S. "Deciduous Eruption In Melbourne Children," Austral. D. J., 9:106 - 108, April 1964.
13. Ricciardi, A. U. "Lateral Growth of the Mandible as Revealed by Serial Intraoral Roentgenograms," Am. J. Orthodont., 41:641 - 642, Aug. 1955. Abstract.
14. Richardson, E. R., Brodie, A. G. "Longitudinal Study of Growth of Maxillary Width," Angle Orthodont., 34:1 - 15, Jan. 1964.

15. Salzmann, J. A. "General Growth Acceleration and Retardation in Relation to Dentofacial Development," Am. J. Orthodont., 40:243 - 258, April 1954.
16. Scott, J. H. "Comparative Anatomy of Jaw Growth and Tooth Eruption," European Orthodont. D. Record, 71:149, Sept. 1951.
17. Scott, James H. "Growth in Width of the Facial Skeleton," American Journal of Orthodontics, 43:366 - 371, 1957.
18. Scott, J. H. and Symond, N. B. R. Introduction to Dental Anatomy. Edinburgh and London: E. & S. Livingstone Ltd., Page 98, 1961.
19. Sillman, J. H. "Some Aspects of Individual Dental Development: Longitudinal Study from Birth to 25 Years," Am. J. Orth., Vol. 51, Jan. 1965.

